Ed. Roberto Greco & Leslie Almberg

Earth Science Education

Global Perspectives

International GeoScience Education Organisation

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AUSTRALIAN SCIENCE INNOVATIONS

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Earth Science Education: Global Perspectives

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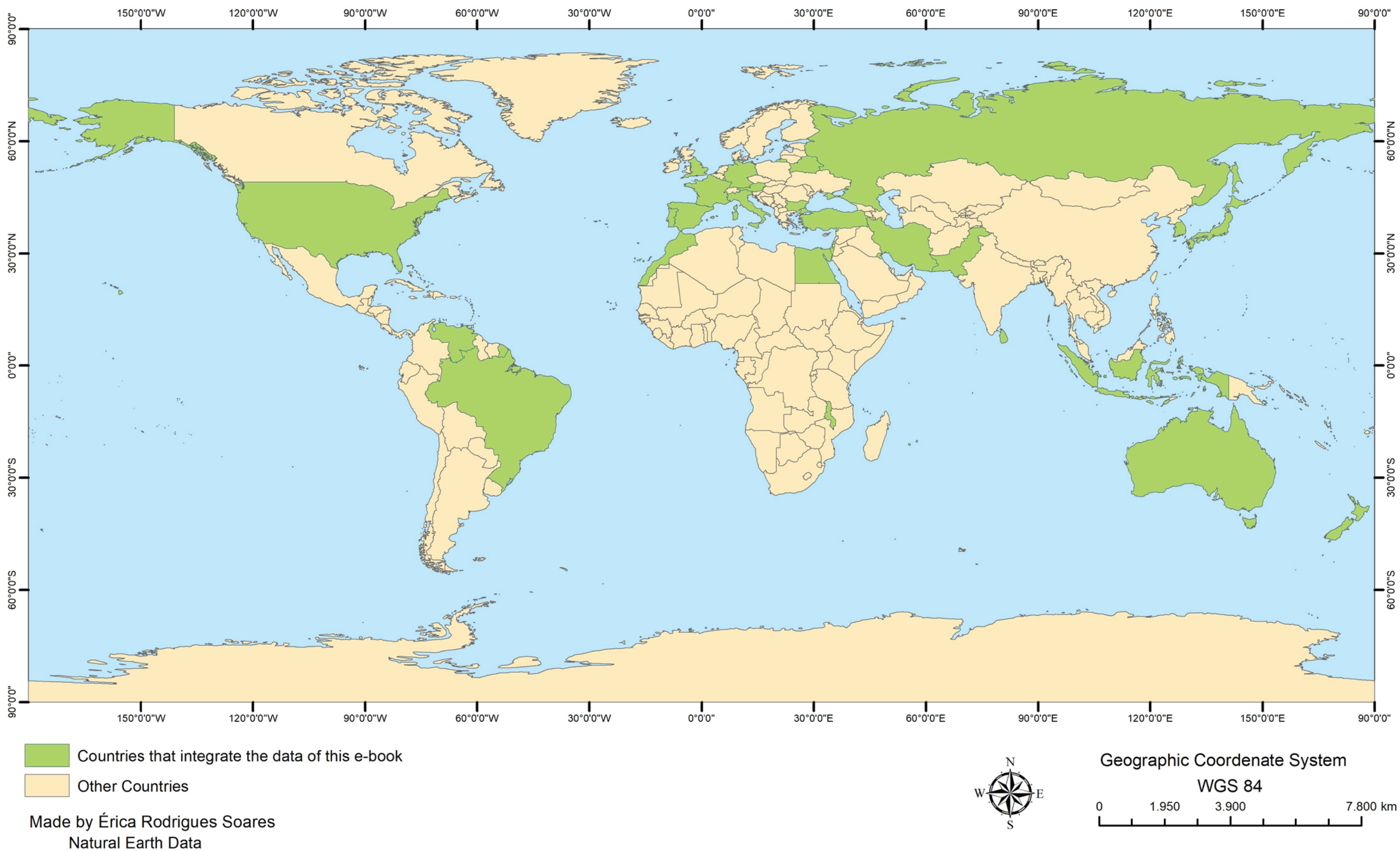

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Preface

This book presents a huge and disturbing gap between the importance of Earth science to the fate of humankind and its low status in schools worldwide.

Nearly every chapter includes an impressive introduction concerning the involvement of Earth Science in almost every critical component of our life on Earth, underscoring how crucial this understanding is for the future of humankind. Some chapters also highlight the central role that Earth Science plays in developing high order thinking skills. It provides learners with the ability to overcome cognitive barriers to spatial and temporal thinking, retrospection, and understanding phenomena across scales of many orders of magnitude, to integrate diverse subjects, and to develop the cognitive capacity for systems thinking. These are the cognitive skills needed to develop environmental insights. Thus, Earth Science can endow citizens with knowledge and abilities to draw conclusions for effective and proper use and conservation of energy, water, and other natural resources. Citizens who understand their environment and its processes are better able to judge and behave in a more scientifically aligned way. Moreover, a few countries present substantial evidence-based data indicating that the Earth systems educational approach can fulfill its potential and, more importantly, how to do it.

However, as manifested by all chapters here, this great potential and the knowledge to fulfill it is not echoed in educational systems around the world. The profile of Earth Science education in schools internationally is low to minimal. The findings of this 2018 collection of 27 countries is very similar to a survey published in 2013 of 32 countries across the globe. The 2013 survey showed that geoscience is taught across the world mostly at the lower age levels by general science or geography teachers who have a weak background in Earth Science. Earth Science as an independent discipline for the high-school level (16-18 year olds) only exists in a small number of countries.

Several chapters herein directly implicate a vicious cycle of ignorance for this situation. This cycle hinges on the improper practice of Earth Science education in most countries. As a result, many students leave the school system with misconceptions and apprehensions about the relevance of Earth Science to their lives and the importance of Earth Science education. These attitudes help perpetuate the narrow perspectives of reductionist education policy makers, including politicians, scientists, and educators. Consequently, we see no appreciable change in the Earth Science status in schools and how it is taught. As a result, this vicious cycle continues for generations without any significant progress.

The International Geoscience Education Organization (IGEO) was formally announced in 2000 with the main purpose to promote Earth Science education at the school level worldwide. Changing the focus and practice of Earth Science in school is a major mechanism of IGEO to fulfil this objective. The International Earth Science Olympiad (IESO) that was the launched by IGEO in 2005, was thought to be a powerful tool to lead IGEO towards meeting its objective. The primary function of IESO is to inspire Earth Science educators to engage with state of the art teaching strategies and techniques. It is expected that mentors take Earth systems inquiry-based education ideas and practices back home and implement them with school teachers in their countries.

The primary intent of IESO is to share, rather than compete. Unfortunately, messages throughout this book indicate that more than a decade after initiation, IESO has had limited influence on the quality and quantity of Earth Science education in schools worldwide, even in the participating countries. It seems that the success of IESO to promote and improve ESE in schools is limited, in part, due to many country's misinterpretation of IESO's main objectives and ethos. For many countries, the competition is the primary driver to participate. Instead of focusing on what can be learned from IESO or contributing to other countries, their ultimate goal is medals. Thus, in most countries, schools are not involved with the preparation process and without such teacher involvement there is no chance to influence Earth Science education quality in schools.

Therefore, bridging the disturbing gap between the potential of Earth Sciences and its low status in schools requires a genuine teaching culture change in schools and even universities. Geoscientists should pave the way for science education within schools through direct political engagement and negotiation with ministries of education and indirectly through mass/social media. Then, they should leave the door open for Earth Science educators with the knowledge and expertise to develop inquiry based Earth Systems Science curriculum and implement it within schools. As many countries lack experienced Earth Science educators, they should invite international Earth Science education experts to work with local teams to prepare them to lead national Earth Science education reforms.

Nir Orion

Editors

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Dr. Roberto Greco's main interests are in nature and learning process. He joins these passions together in his activities as an Earth science educator and researcher.

After years as a secondary school natural science teacher in Italy and two years at the Ministry of Education, he moved to Brazil to work as an assistant professor at University of Campinas. He lectures on basic Earth science to geology, biology and geography students and Earth science pedagogy for future teachers. He supervises Master's and PhD students undertaking research devoted to preparing future generation for global changes.

He is involved in the international project Earth Learning Idea, previously coordinating translation into Italian and now into Brazilian Portuguese: http://www.earthlearningidea.com/

He trained the first Italian team selected for the International Earth Science Olympiad (IESO), and helped train the first Brazilian IESO team. He was the main organizing chair person for IESO 2011 in Italy and the scientific commission chair of IESO 2015 in Brazil. In 2015, he created the first Brazilian Geography Olympiad and in 2017 organized the first Brazilian Earth Science Olympiad.

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Leslie D. Almberg

Dr. Leslie D. Almberg is an impassioned Earth Science teacher with over 20 years of field and lab-based geology experience. Dr. Almberg gained a wealth of first-hand experience with all things related to plate tectonics in her training as a physical volcanologist, experimental petrologist, seismic data analyst, and research assistant at the Alaska Volcano Observatory. Her studies of volcanic conduits, degassing processes, eruption dynamics, and late-stage alteration processes have taken her around the globe exploring the Ring of Fire and beyond.

Dr. Almberg has worked with students and teachers extensively throughout her education and career, earning accolades and recognition from students, institutions, and government bodies for her efforts. In 2012, she was awarded a Citation for Outstanding Contributions to Student Learning from the Australian Government Office for Learning and Teaching.

In addition to her role as the Deputy Director for the Australian Earth and Environmental Science Olympiad, she is currently the Teacher Earth Science Education Program Coordinator for the state of Victoria, a board member for the Australasian Universities Geoscience Educators Network, and casual lecturer at Monash University. She is a contributing author to the Earth Science Western Australia Year 11/12 Exploring Earth and Environmental Science textbooks, and involved in the educational development for the AusGeol.org virtual library of Australia project. E-mail: lesliedalmberg@gmail.com

Chapter 1

The IESO selection process: how Australia does it…

Greg McNamara and Bronte Nicholls

Abstract

The Australian education system is spread across six states and two territories. Each jurisdiction operates its own education and teacher registration system. A recently implemented national curriculum has, for the first time, produced a relatively uniform approach to education, including science education, across the nation. Using an Earth Systems Science approach, Earth and space science forms 25% of the science curriculum from Foundation to Year 10. Earth and Environmental Science is offered at senior level – Years 11 and 12 – in four states and one territory.

The Australian Science Olympiad program is administered by Australian Science Innovations (ASI), a not-for-profit organisation. Registration is open to all secondary school students, particular those in years 10 and 11, to sit national exams designed to identify 24 of the most able students in each of Biology, Chemistry, Earth and Environmental Science and Physics. Each discipline trains up to 24 students at a residential Summer School in January with staff employed by ASI. The Summer School programs are roughly equivalent to a first year university course in each subject.

Summer School students are assessed for their academic skills and the most able are invited to represent Australia at the respective Olympiad. Students selected to represent Australia at the International Earth Science Olympiad attend a further week of training in July.

Keywords: Australia, Earth System Science, IESO, Australian Science Innovations

1.1 The Australian education system

1.1.1 History

Australia is a federation of six states and two significant internal territories and is the only country on Earth to occupy an entire continent (Fig. 1.1). Australia is the 6th largest nation by area on Earth but with a population of approximately 24 million has a low average population density. However, with the majority of inhabitants living in large cities near the coast, rural and remote Australia is very sparsely populated and major cities have population densities more typical of cities elsewhere in the developed world.

Fig. 1.2 The structure of the Australian Curriculum - Science.

Source: Australian Curriculum v8.1 n.d.4

Following European settlement in 1788 but prior to federation, the Australian continent was gradually divided into six self-governing British colonies. On 1 January 1901, the colonies collectively became states of the Commonwealth of Australia but each state kept the system of government and its upper house / lower house legislature that was in place prior to federation with the federal government assuming responsibility for overarching matters of national importance. The two internal territories, the Northern Territory and the Australian Capital Territory, have different governance arrangements but are now effectively self-governing and generally treated as states.Consequently, each state and territory is responsible for administering its own education system and maintains its own government department to administer the delivery of education, formulate the state curriculum, employ teachers and allied professionals, set the standards students must meet and the exams that they must sit. The federal government also maintains an education department which aims to provide quality learning outcomes for all students through the provision of education services to all stakeholders with a range of programs and funding arrangements that reflect federal government policy (Department of Education and Training, 2015).

Historically, each state and territory developed its own school curriculum for preschool (now known as Foundation in Australia) and school years 1 to 12. This eventually led to significant inconsistencies between jurisdictions, although the curricula generally had similar standards and content (Aussie Educator, 2016). There were numerous attempts through the latter half of the twentieth century to solve the problems induced by state to state inconsistencies via development of a national curriculum. These attempts failed to win the support of all jurisdictions, often due to minor regional priorities, hence each state and territory bureaucracy developed their own curriculum content and delivery models for most of the time since federation.

1.1.2 The National Curriculum

The first decade of the current century saw a renewed interest from a large number of stakeholders in the development of a national curriculum. A national independent statutory authority, now known as the Australian Curriculum, Assessment and Reporting Authority (ACARA) (Australian Curriculum, Assessment and Reporting Authority, n.d.1), was established to oversee the development of a national curriculum through liaison with state and territory education departments, extensive consultation with all stakeholders (Australian Curriculum, Assessment and Reporting Authority, n.d.2), and the employment of world class curriculum development professionals (Australian Curriculum, Assessment and Reporting Authority, n.d.3). Writing the now fully adopted national curriculum took place over several years, with the task divided into two sections: Foundation to Year 10 and Senior years (Years 11 and 12). Each section addressed both the overarching curriculum needs for each year level and the specific content to be developed for each subject area in each year level (or a band of several levels);

34 learning areas and subjects in all (Australian Curriculum v8.1, n.d.1). The Foundation to Year 10 Australian Curriculum recognises the central importance of disciplinary knowledge, skills and understanding, general capabilities and cross-curriculum priorities (Australian Curriculum v8.1, n.d.2). The senior subjects build on this base through Years 11 and 12, where much greater in-depth learning is undertaken.

1.1.3 School structures and the curriculum

The detailed structure of the Australian school system varies from state to state but in general students commence formal schooling around age 6 and most students attend a preschool year. The preschool year, known as Foundation in the National Curriculum, is the start of Primary School, which encompasses Foundation and Years 1 to 6.

Secondary School commences immediately after Year 6 encompassing Years 7 to 12. In some areas secondary schooling is divided between Year 7 to 10 school campuses and Year 11 and 12 senior secondary campuses. In some rural and remote areas primary and secondary schooling takes place in the one combined campus.

No matter how the Primary and Secondary schools are physically structured, the Foundation to Year 10 curriculum is partly delivered in the Primary School environment and partly delivered in the Secondary School environment. This presents some challenges for teaching science as most Primary School teachers do not have a strong science background. Secondary School Science is, ostensibly, delivered by a teacher with some formal university level training in science, although the majority of science teachers have little or no Earth Science training at university level.

1.1.4 Teacher education and qualifications

Australian school teachers are usually trained at university by specialist departments delivering Bachelor of Education degrees. Some degrees specialise in Primary or Secondary education, although some offer an F-12 degree that qualifies graduates to teach at any level.

Most students who enrol in a specialist Bachelor of Education (Primary) degree do not have a strong science background and most Bachelor of Education (Primary) degree training in Australia does not focus deeply on specifically teaching science. Bachelor of Education (Secondary) degrees in Australia allow students to specialise in several subject areas including science. This specialisation is further increased by advanced studies in a discipline such as Biology, Chemistry, Earth Science or Physics. Graduates employed as science teachers usually teach the general junior science classes as well as senior classes in their specialist area, although the number of Earth Science specialists has always been much lower than Biology, Chemistry or Physics specialists. The result is that many senior Earth and Environmental Science classes are taught by science teachers without formal qualifications in Earth Science.

Historically, science graduates have also entered the teaching profession through a one-year Graduate Diploma of Education. This route was often followed by Earth Science professionals seeking a career change.

All degree and graduate diploma programs require students to spend time on placement in the classroom with a supervising teacher. Once a prospective teacher successfully completes all course work and placements for the degree or diploma, they apply for teacher registration in the state they intend to work in. New teachers initially obtain a provisional registration, which is only upgraded to full registration once they demonstrate proficiency (Australian Institute for Teaching and School Leadership, n.d.).

1.1.5 Science in the National F to 10 Curriculum

Science is one of eight key learning areas within the National F to 10 Curriculum and is a subject in its own right (Australian Curriculum v8.1, n.d.2). In the Primary School environment, the classroom teacher or team of teachers in the school determine how the mix of eight learning areas is delivered. Students typically receive all lessons in one non-specialised classroom. In contrast, Secondary School teachers specialise in teaching science and work to the curriculum within a timetable designed to deliver an adequate number of student contact hours for each subject. Subjects requiring specialist facilities, such as laboratories, are delivered in appropriate rooms. The Science subject is structured around three strands: Science Understanding; Science as a Human Endeavour; and Science Inquiry Skills (Australian Curriculum v8.1, n.d.3) (Figure 2). In a more traditional syntax these strands might be called Content, Context, and Practical Skills. The strands are interrelated and delivered in an integrated fashion. Some states are more prescriptive than others about how subject content is delivered, but the classroom teacher or the team of teachers at each school generally determine the overall subject mix and delivery methods.

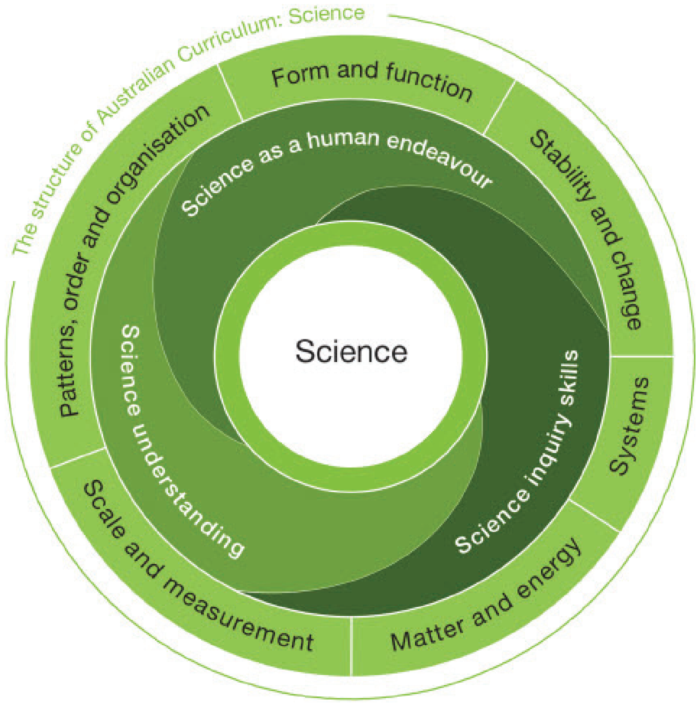

Fig. 1.2 The structure of the Australian Curriculum - Science.

Source: Australian Curriculum v8.1 n.d.4

Across all of the science content six key ideas are addressed: Patterns and organization; Form and function; Stability and change; Scale and measurement; Matter and energy; and Systems (Fig. 1.2). These key ideas are designed to support the coherence and developmental sequence of science knowledge within and across year levels (Australian Curriculum v8.1, n.d.4).

For each year level, Foundation to Year 10, Science Understanding is divided into four equal areas of content or sub-strands: Biological sciences, Chemical sciences, Earth and space sciences, and Physical sciences (Australian Curriculum v8.1, n.d.5). Even though the content delivery is at the discretion of the classroom teacher, working within state education department guidelines, in each and every year Earth and space sciences is designated 25% of the overall content of the Science subject.

Science teaching in Foundation to Year 10 is supported by a variety of commercially available textbooks written for the Australian Curriculum. Using these books in state schools is at the discretion of the state's education department, therefore, each state may prescribe a preferred textbook, especially at Secondary School level. However, other schools may use different textbooks and all teachers use a variety of sources that help them meet the educational outcomes required by the curriculum. The Australian Academy of Science published a suite of Primary level inquiry-based units that provide clear and practical teaching approaches in response to the shortage of good quality support materials for Primary School teachers. It includes comprehensive teacher advice and all student resources required for classroom use (Primary Connections, n.d.). This is complemented by an equivalent set of materials suitable for Secondary Schools (Science by Doing, n.d.). All these printed and online resources are updated to meet the new Australian Curriculum and all contain appropriate Earth and space content for each year level.

1.1.6 Earth Science in the F to 10 National Curriculum

The Earth and space science sub-strand is concerned with Earth's dynamic structure and its place in the cosmos. The key concepts developed within this sub-strand are: Earth is part of a solar system that is part of a larger universe; and Earth is subject to change within and on its surface, over a range of timescales as a result of natural processes and human use of resources (Australian Curriculum v8.1, n.d.3).

While the Earth and space sciences sub-strand is designed to encompass all relevant material, it is inevitably a compromise. Hence, the depth and degree to which materials are introduced to students is variable from classroom to classroom and teacher to teacher. It is however well complimented by the other sub-stands allowing students to have a basic understanding of key Earth Science concepts such as rocks and minerals, plate tectonics and uniformitarianism, a basic understanding of the solar system and planetary dynamics, as well as an appreciation of the scientific method and how it applies to Earth Science and Astronomy by the end of Year 10.

1.1.7 Science in the National Senior 11 to 12 Curriculum

Historically, senior science subjects available in most secondary schools only included Biology, Chemistry, and Physics. These traditional science subjects, along with one or more mathematics subject, always paved the pathway for students intending to study science at an Australian university. A limited number of secondary schools in most states also offered

Geology as a senior science but, even at the height of the mineral booms in the twentieth century, it was never as popular as the three traditional subjects because Australian universities did not set senior secondary Geology as a Bachelor of Science degree entrance prerequisite, while subjects such as Chemistry were. Additionally, university geology courses did not set senior secondary Geology as an entrance prerequisite McNamara, 2012).

Since 1970, Geology as a senior subject progressively became less popular with students and most states discontinued offering Geology in the senior years when student numbers and the number of schools teaching the subject, dropped to impractically low numbers. This coincided with a rise in the number of alternative science subjects that schools could offer including Psychology and Environmental Science (McNamara, 2012).

Many states discontinued teaching senior Geology when they commenced teaching Environmental Science. This subject proved much more popular with students, albeit with only a limited number of schools offering it and enrolment numbers significantly lower than in Biology, Chemistry, and Physics.

In Secondary School Years 11 and 12, science subjects are taught in considerable detail and although in Australia they are most often seen as a preparation for university the content level in each subject is nearly comparable to many overseas first year university courses. This is reflected in the content level found in the senior Geology textbook, *Perspectives of the Earth*, produced by the Australian Academy of Science for Australian schools in 1983 (Cook and Clarke, 1983).

1.1.8 Earth Science in the Senior 11 to 12 Curriculum

In the initial discussions on the Australian National Curriculum for senior science subjects, it was proposed that a fourth senior science subject, Environmental Science, be established. The proposed subject would be written to complement, and be of equal weight to, the existing national subjects, Biology, Chemistry, and Physics. At the time, New South Wales was offering a modestly successful Earth and Environmental Science subject and Earth Science Western Australia (Earth Science Western Australia, n.d.1) had successfully worked with the Western Australian government to produce a senior Earth and Environmental Science curriculum that was proving very popular with students. It had generated a dramatic reversal in declining student enrolments in Geology (Earth Science Western Australia, n.d.2) and provided the impetus for a variety of stakeholders to lobby for the new national subject.

The lobbying was successful and the fourth science subject recognised by ACARA became Earth and Environmental Science (Australian Curriculum v8.1, n.d.6). This subject, a blend of traditional geology and environmental science subject matter, is a significant compromise for those lobbying solely for a Geology or Environmental Science course, but it has proved a winner with students in states that have adopted it.

Not every state follows the same approach as the national curriculum, but in general the content and the aims are consistent across the nation.

At the time of writing, this subject has not been fully implemented in some states and, in a departure from the full implementation nationwide of the F to 10 Curriculum, the states of Tasmania and Victoria have decided to continue offering their Environmental Science courses and not offer Earth and Environmental Science. South Australia will implement a new Earth and Environmental Science course in 2017, which replaces the existing Geology course (South Australian Certificate of Education, 2016). It is noted Victoria has recently rewritten its Environmental Science course and the new version does contain considerably more Earth Science content (Victorian Curriculum and Assessment Authority, 2015). The Northern Territory does not currently offer either subject.

Senior level Earth and Environmental Science teaching is supported by several purpose written textbooks with different jurisdictions using different books.

The Australian Earth and Environmental Science Curriculum takes an Earth Systems approach and is divided into 4 units that are taught over 2 years. In this context the term *Environment* encompasses terrestrial, marine, and atmospheric settings and includes Earth's interior. Environments are described and characterised with a focus on systems thinking and multidisciplinarity rather than with a particular ecological, biological, physical, or chemical focus (Australian Curriculum v8.1, n.d.7).

1.2 The Australian Earth and Environmental Science Olympiad program

1.2.1 Background

Australia has participated in the International Biology, Chemistry, and Physics Olympiads for several decades. This participation is managed by a not-for-profit organisation, Australian Science Innovations (ASI) (Australian Science Innovations n.d.1). ASI is funded by a mix of government and industry grants, partnerships, assistance in-kind and participant contributions.

In 2012, after the establishment of the National Curriculum Earth and Environmental Science subject for senior students and the consolidation of Earth and space science in the F to 10 Curriculum, numerous stakeholders lobbied ASI to start an additional program to select and train a national Australian team to compete at the International Earth Science Olympiad (IESO). Coincidentally, ASI was renewing partnership arrangements with a number of key stakeholders and in 2013 support was provided through the BHP Billiton Sustainable Communities fund for all three existing programs plus the addition of a fourth program to select students for Australian teams to attend the IESO. Additional funding came through the Australian government Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education. Start-up funding for the Earth and Environmental Science Olympiad Program was also provided by the Australian Geoscience Council, a peak body representing eight major Australian geoscientific societies with a total membership of over 7000 (Australian Geoscience Council, n.d.).

In early 2014, ASI appointed a program director and deputy program director tasked with establishing an Australian selection and training program for Australian representation at IESO events from 2015 onwards. The new appointees attended the 2014 8th IESO in Spain as observers in this development process.

1.2.2 Student selection from the national pool

The ASI selection process for Biology, Chemistry, and Physics Olympiad students has operated successfully for many years (Australian Science Innovations n.d.2). We decided to follow this model both because of its historical success and the reduction in operational costs by extending the volume of existing tasks performed by support staff rather than implementing an entirely new regime.

The first step in the student selection process is writing a national entrance exam (Australian Science Innovations n.d.3). This two-hour exam is designed to identify up to 24 of the most capable students from the pool of students nation-wide who choose to sit the exam. Approximately1000-1500 students sit each exam for Biology, Chemistry, and Physics every year. Consequently, the design of this exam is critical for selecting highly capable students who can be further trained to compete well at the International Olympiad level.

Given that:

a) senior Earth and Environmental Science is not a widely taught subject in any jurisdiction;

b) it is understood, at least anecdotally, that the Earth and space component of F to 10 Science was somewhat ineffectively taught in many schools; and

c) students in Year 12 are not eligible to compete at the IESO in the following year,

it was determined that most students who might sit the national Earth and Environmental Science Olympiad entrance exam would either only be in Years 9 or 10 and have relatively poor Earth and space content knowledge or be in Year 11 studying science but most likely not Earth and Environmental Science.

These factors influenced the design of the Earth and Environmental Science Olympiad entrance exam such that:

a) no Earth and space content knowledge beyond Year 10 curriculum requirements could be assumed; and

b) it could determine a student's ability to analyse and synthesise complex information. Hence, the majority of questions were based on information provided in the questions themselves and focused on thinking ability rather than memory.

Although enrolment in the first Earth and Environmental Science Olympiad entrance exam was anticipated to only be 200-300 students, we decided that the questions needed to be extremely challenging to easily identify those most able to think through and appropriately solve problems from a small pool of candidates.

Because the Earth Systems Science approach to teaching the subject is used in Australia it was also determined that the exam questions should represent a balance of the content as it is distributed across the spheres: Atmosphere, Biosphere, Geosphere, Hydrosphere, and Astronomy. Consequently, critical friends (external content and teaching experts) were invited to review the exam questions to ensure they were scientifically valid and set at a level appropriate to select highly capable Australian Year 9 to 11 students from those who would take the exam.

The structure of the 2 hour exam varies from year to year but generally consists of 20-40 multiple choice answer questions and 15-30 short written answer questions. Unless otherwise specified, the multiple choice questions are worth 1 mark each and the written answer questions values range from 1-15 marks each. Multiple choice questions are answered using a pre-printed sheet that is marked by machine when returned to ASI. Written answer questions are answered in spaces provided on the exam paper and returned to ASI for marking by Earth and Environmental Science Olympiad program staff.

The usual $10 ASI exam entrance fee was waived to encourage students to sit the first Earth and Environmental Science Olympiad entrance exam. Promotional materials sent to teachers also explained why students with no senior Earth and Environmental should be encouraged to take the Earth and Environmental Science Olympiad entrance exam. This material focussed on our search for problem solving abilities, explaining that any lack of in-depth content knowledge would be addressed by the subsequent training from the Earth and Environmental Science Olympiad program receive by selected students.

Teachers are responsible for managing Earth and Environmental Science Olympiad entrance exam enrolments. They must register students online and registrations can only be made by teachers. An enrolment cut-off date is set several weeks from the examination day so that final numbers can be determined and the appropriate number of exam papers printed. The correct numbers of exam papers for each school are then couriered to the teachers at each school managing the process. Students nation wide then sit the exam on the appointed day supervised by their teachers. Teachers then return all completed papers to ASI for marking.

The inaugural Earth and Environmental Science Olympiad entrance exam in August 2014 (Australian Science Innovations n.d.4) identified 15 top students to invite to attend the intensive Summer School in January 2015 (Australian Science Innovations n.d.5). As this was the program's inaugural year, we decided to limit the intake to 15 students and the Summer School program to 14 days (including travel to and from the venue). The 2016 intake aimed for 24 students to attend a 17 day program. This is in line with the ASI program for Chemistry and Physics and is to be the future standard Earth and Environmental Science Olympiad Summer School intake and duration.

All students who sit the exam and return a completed paper receive a certificate to acknowledge their outstanding effort. Students selected for Summer School receive a gold medal and a formula is applied to the remaining results to award silver and bronze medals to the other highest achievers. These certificates and medals are sent to the schools to present.

1.2.3 The Australian Earth and Environmental Science Olympiad Summer School

Students who top the exam are invited to attend the Australian Earth and Environmental Science Olympiad Summer School (Australian Science Innovations n.d.5). This is an intense training program held at the Australian National University in January, during the Australian summer school break between the end of Term 4 and the start Term 1.

Students who accept the Summer School offer are asked to financially contribute to the program. In 2016 the fee was AU $1900 each. However, it is ASI policy that inability to financially contribute is not a deciding factor and they assist students facing financial hardship to find ways to cover these costs. The Earth and Environmental Science Olympiad Summer School is coincident with the Biology, Chemistry, and Physics Summer Schools and all students and staff from all four disciplines live on campus in the residence halls that are otherwise vacant for the summer. This creates a collegiate atmosphere and simplifies the process management. Each discipline runs a slightly different type of Summer School program but the aims of each are essentially the same. To:

a) teach Summer School students high level science; roughly the equivalent of first year university studies at an Australian university; and b) select students from the Summer School cohort for the Australian team. In Earth and Environmental Science this involves delivering a mix of content covering the basics students should have encountered in the F to 10 Earth and space science curriculum at school plus higher level materials. The goal is to extend students' understanding and knowledge to that of a top undergraduate student at the end of first year university. Teaching is conducted using a variety of styles by seven to eight staff members, several of whom are qualified geologists and/or qualified teachers. Other staff include current science postgraduates and undergraduates who are Summer School or Olympiad alumni. All senior staff are financially rewarded for their efforts and alumni/student staff receive a gratuity. Travel, food and accommodation costs of all staff are fully paid for by the program. During the Earth and Environmental Science Olympiad Summer School students work through lectures, hands-on practicals and field experiences. Additionally, they receive lectures and practical instruction from internationally renowned Australian scientists and visit world famous laboratories and institutions based in Canberra. They are constantly challenged by new concepts and content that commences each day immediately after breakfast and concludes several hours after dinner in the evening. Students also face in-class assessments most days and given constant feedback on how well they are progressing. Students have only one rest day around the middle of the Summer School program. At the end of Summer School students sit in-class final theory and practical exams.

The combined results of the final exams and other assessments are used to determine the top students in the cohort.

1.2.4 Post-Summer School team training

The Earth and Environmental Science Olympiad Summer School ends around January 22 and selected students are offered a place on the team by mid-February. Students who accept the offer are asked to financially contribute to their ongoing training and attendance at the IESO. In 2016 the fee was AU $2400 each. However, it is ASI policy that inability to financially contribute is not a deciding factor and students facing financial hardship are assisted to find ways to cover these costs. Previously, some students have had some of their costs off-set by donations from professional societies and other groups.

Membership of all Olympiad teams is formally announced by ASI at a special ceremony at the Australian Parliament House, Canberra, in June. Team members are presented with a nationally appropriate blazer and congratulated on their achievement by a senior member of the Australian government, usually the Minister responsible for Education.

All Australian Olympiad students attend extra Olympiad-orientated training prior to travelling to their respective Olympiads. Biology, Chemistry, and Physics training occurs during the short break between Term 1 and Term 2 in April or May allowing them to prepare for their Olympiad events in July. However, because the IESO is held in August-September, we determined the Earth and Environmental Science Olympiad training is best set in the break between Term 2 and Term 3 in July. While this creates a six month gap between Summer School and their team training, having a shorter period between the team training and the IESO is regarded as a better option.

IESO team training involves a week long residential camp, based at the Australian National University's coastal campus, Kioloa (Australian National University, 2015). During this camp, students gain valuable insights into their studies because the spectacular location affords access to world-class outcrops of a wide range of rock types at the interface with coastal marine, estuarine, and freshwater environments. This provides staff-mentors and students with excellent opportunities to discuss all aspects of Earth Systems Science while also spending time working through past IESO exam papers and other challenging test materials. The location also provides good opportunities for astronomy, weather permitting.

After the training week, mentors do not met with the students again until they arrive at the airport to board their flight to the IESO. By this time the four team members are comfortable communicating with their mentors via email and telephone allowing additional training to occur through these mediums. Mentors are, however, cognisant of the fact that all team members are still fully engaged in their schools and one or more of them will be in their final year of studies before attending university. It is therefore very important that all staff and students involved in preparations for the IESO understand that the students' school work and overall wellbeing must take precedence over IESO training.

1.2.5 Outcomes of this selection process

There can be no doubt that the entrance exam does identify high ability students with excellent science skills and problem solving ability. These students have good content knowledge in some science areas but not others. Most students' weakest area of content knowledge is in the Earth and space sciences.

More often than not, the selected students' understanding of Earth Systems Science is limited. However, their ability to rapidly process new information and use it to problem solve is not. Staff involved in the first two years of the Summer School training to date are constantly amazed by the ability of these students to meet the challenges put before them and to then continue to learn and develop under their own recognisance.

These abilities are reflected in the Australian team's results at the 9th IESO in Brazil (1 gold and 2 silver medals plus 2 international team awards for individual students). Hopefully this will continue!

1.2.6 Impact of the Olympiad program

At the time of writing the Australian Earth and Environmental Science Olympiad program is in its third year. It is too early to determine if the program has had any impact on student study intentions as they transition from Secondary School to university. However, the career outcomes of students participating in the program will be monitored. It is expected that some high ability students who have experienced the Australian Earth and Environmental Science Olympiad program will include some Earth Science in their undergraduate studies when they might not have done so otherwise. It is also hoped some will even find an Earth Science career pathway!

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Greg McNamara

Greg has a Bachelor of Science with First Class Honours in Geology from Monash University and a research-based Master of Science in Geology from James Cook University. While teaching undergraduate Earth Science to both science and education students at JCU, Greg became interested in education and completed a Graduate Diploma of Education through JCU while managing the Earth Science department's collections and facilities and helping CSIRO establish the North Queensland Science Education Centre.

After a two-year placement in Broken Hill managing the GeoCentre Interactive Rock and Mineral Museum, Greg moved to Canberra to establish and run Geoscience Australia's Earth Science Education Centre where he ultimately managed the education program before starting a consultancy in Victoria.

Greg has provided quality geoscience education and outreach advice and products to national and international clients including Australian Science Innovations since 2004. In addition to his role as Earth and Environmental Science Olympiad Program Director, Greg is Executive Officer of the highly successful Teacher Earth Science Education Programme. He is also editor of GeoEdLink, the e-newsletter of the Australian Geoscience Council, and GEOZ, the e-newsletter of the Geological Society of Australia. *Australian Science Innovations. E-mail: greg.mcnamara@asi.edu.au*

Bronte Nicholls

Bronte initially undertook studies in Natural Resources at the University of Adelaide, changing paths to pursue science teaching through a university degree at the University of South Australia. In 2003, her years of teaching and research into science education in the field of education led to her completing a Doctorate of Science Education through Curtin University, Western Australia.

Early in her career, Bronte was recognized for her dedication to geoscience education and in 1992 was awarded the Australian Science Teachers Association/ CRA Fellowship allowing her to travel to the United Kingdom to participate in the first conference of the *International Geoscience Education Organisation (IGEO)* and to visit schools across the UK; she has been a Senior Officer of the IGEO since 2003. She has travelled extensively, delivering academic papers about Geoscience Education and strategies to reduce educational disadvantage.

She has held a range of non-school based policy positions with the Department of Education and Children's Services, SACE Board and future SACE Office. The majority of her career has been in school-based leadership positions in both non-government and government schools and has been Director of Innovative Pedagogy at the Australian Science and Mathematics School in Adelaide since 2010. *Australian Science and Mathematics School. E-mail: bronte.nicholls@asms.sa.edu.au*

Chapter 2

The Austrian Landscape of Geoscience Education and the National Selection Process for IESO

Sabine Seidl

Abstract

The chapter elaborates on the status quo of Austria's geoscience education as well as the genesis of Austria's participation at the IESO since 2012. Commencing with geoscience implementation in primary schools (*Sachunterricht*) and in secondary schools (*Geography and Economic Studies)* the article also examines how geoscientific content is split up among several scholastic subjects throughout different academic years. In Austrian secondary education *Geography* was changed in 1962 to *Geography and Economic Studies* to include economic issues in addition to geographic. This significant change reduced the allocation for physical geography. However, major geoscientific content is embedded in the Austrian biology curriculum.

Next the Austrian IESO selection and preparation process is highlighted, including successful cooperation with sponsors and scientific institutions nationwide. The article closes with an examination of the new national selection process in place since 2015 at Styrian High School in Leoben. This school implemented a dominant geoscientific curriculum and thus represents the national center for the Austrian IESO selection process.

Keywords: Austrian school system, Sachunterricht, Geography and Economic Studies, geoscience high school in Leoben

2.1 The Austrian School System

Austria offers a variety of school types. Table 2.1 provides a broad overview of the entire Austrian school system.

Tab. 2.1 The Austrian school system (simplified)

Post-secondary courses (ISCED 5B)	University colleges of teacher education (ISCED 5A)	Universities of applied sciences (ISCED 5A)	Universities (ISCED 5A, 6)
Secondary school leaving certification (Matura), VET diploma		Higher education entrance examination, Berufsreifeprüfung	
Age 14-18/19	Higher secondary (ISCED 3A/3B/3C/4A)		
Age 10-14	Lower secondary (ISCED 2)		
Age 6-10	Primary school (ISCED 1)		
Kindergarten			

By courtesy of http://www.bifie.at

Kindergarten (age ~3 to 6) usually offers a bilingual pathway, ensuring a first exposure to English or Slovenian (southern Austrian counties). Subsequently, primary schools (age 6 to 10) also offer age-adequate foreign language preparation (geoscience implementation at this age is addressed in the next section).

In lower secondary education (age 10 to 14), students may choose between several types of secondary education with the focus ranging from economic to technical, foreign languages or natural sciences. After lower secondary education students may continue to attend (age 14 to 18 or 19) the chosen school type or switch to another higher secondary education institution. Higher secondary education offers the possibility to graduate with A-levels.

Upon graduating from high school, students have the option to choose an academic career and attend university or a university college to graduate with Bachelor's, Master's and eventually PhD degrees. Post-graduate studies are very common in Austria and highly appreciated in all academic realms.

2.2 Geoscience Implementation in the School System

2.2.1 Primary School

Austria's youngest students (age 6 to 10) learn about geoscience quite early; in primary school they have a subject called *Sachunterricht* comprised of age-appropriate biology, chemistry, physics and geoscience content. Moreover, young students get a glimpse of economics and how the world is connected by it, how a community works or how time, space and technical issues affect their lives.

Children get to know their immediate geographic surroundings, with all of Austria and the European Union included in the curriculum. Some primary schools also offer practical work in natural scientific laboratories to discover natural principals, weather, or other basic scientific phenomena.

A further important aspect of primary school curriculum is elaboration on the connection between human beings and nature. Apart from learning different landforms and water bodies, they reflect on environmentally responsible living.

In primary school one teacher is responsible for all subjects in a class (except for religious studies). Teachers earn a teaching degree from a University College for Teacher Education.

2.2.2 Secondary Education

Classic geography is taught by teachers with a university degree in Geography; they teach the Austrian school subject *Geography and Economic Studies*. In secondary schools (age 10 to 18 or 19), geoscience education is slightly differentiated depending on the school type. Specific to Austria is the fact that after 1962 *Geography* was changed to G*eography and Economic Studies* to include economic issues. Therefore, geoscience education is included within the two main areas, geography and economics. This significant change reduced space for physical geography within the newly created subject. However, several geoscientific issues are found in the *Biology* curriculum (see Table 2.2). Geochemical content is a small part of the *Chemistry* curriculum taught by chemistry teachers. Finally, astronomy, cosmology or astrophysics are found in the *Physics* curriculum taught by physics teachers.

With the exception of the geoscience high school in Leoben, which has a dominant focus on Earth sciences (HTL Leoben, Styria, http://www.htl-leoben.at), the traditional high school curriculum is comprised of the content outlined in Tab. 2.2. There are, however, slight variations in curricula among secondary school types, which are detailed for any Austrian school at http://www.bmbf.gv.at:

Table 2.2 Subjects with geoscience-relevant content

Year	Traditional high school curricula – abbreviated and summarized	
	Geography and Economic Studies	*Biology* *(geoscience-relevant content only)*
1	natural areas working with maps, pictures and globes economic differences in selected parts of the Earth how resources and energy are claimed and reclaimed simple economic structures global regularities of climate zones	ecology of forests environmental protection
2	natural areas living in metropolitan areas industry, facilities and enterprises Earth as a living and economic space	forest ecosystems national hydrosphere
Year	Classic high school curricula – abbreviated and summarized	
	Geography and economic studies	*Biology* *(only geoscience-relevant content)*
3	living space Austria: landscape studies with maps and other devices evironment living space coined by human beings first insights into the working world connection Austria-Europe	ecosystem soil and agricultural usage cycle of materials
4	community Europe centeres and peripheries of the world economy living in a world of varieties globalization environment	rain forests oceans environment and pollution

5-6	landscape ecology: zones of the Earth how Earth can be divided into natural, cultural political and economical points of views natural areas population and society people and economic needs natural resources diversity and unity: European Union	distribution of resources agricultural issues cycle of materials bioplanet Earth: composition and structure of Earth, geodynamics development of Austrian landscapes climate change, sustainability
7	Austria: region, society and economy from 20th century to today demographic development and sociopolitical implications economic zone Austria enterprises and professional orientation	Biology in year 7 only in highschools with focus on natural sciences energy, traffic, tourism and sustainable developments
8	globalization: chances and challenges political and economic systems cities as living space and economic centers money and currencies	No geoscientific content

Source: http://www.bmbf.gv.at

2.3 National IESO Selection and Preparation Process

2.3.1 History

In 2012 Sabine Seidl, head of the Austrian IESO Delegation, participated in the IESO in Argentina as an observer. She gained valuable insights there with respect to the organization, task selection, translation and overall performance of an IESO. Financial support for Austria's participation in 2012 came mainly from governmental institutions.

From 2013 onwards Austria was able to front a national team (Table 2.3).

Tab. 2.3 Student participation and gender distribution. (* participants' county of origin)

IESO	Total participating students	Counties*	Gender	
			Male	Female
2013	3	Carinthia	1	2
2014	4	Carinthia, Styria	1	3
2015	4	Carinthia, Styria	1	3

2.3.2 Scientific and organizational team

Peter Holub **Initial coordination**
University College of Teacher Education
Carinthia

Sabine Seidl **Head of IESO National team| IESO Mentor**
University College of Teacher Education
Carinthia
Chemistry teacher

Bernhard Sallay **IESO Mentor**
Peraugymnasium Villach Austria
Physics teacher | Astronomer

Kirsten von Elverfeldt **IESO Mentor** (from 2014 onwards)| Alpen Adria University
Klagenfurt
Professor, Department of Geography and Regional Science

2.3.3 Sponsorship

As expected, landing financial sponsors and infrastructural supporters was a challenging undertaking. Eventually, meetings with governmental officials and enterprises with geoscientific background launched in spring and summer 2012. Intense talks and meetings followed to finally conclude the entire financing and realization of Austria's IESO participation. The following institutions are now major supporters with respect to infrastructure, organization, and financing:

- Austrian Federal Ministry of Education
- County of Carinthia
- City of Klagenfurt
- Landesschulrat für Kärnten
- Entwicklungsagentur Carinthia
- University College of Teacher Education Carinthia
- Regional network for natural science and mathematics Carinthia

- Inizia Society
- Industrial sponsors

2.3.4 Selection Process

The initial national selection commenced by contacting geoscience teachers across Austria by sending information folders to schools. Two of eight Austrian counties were involved at that point. Since IESO participation was still a pilot project back then, we had to select from a small number of students. However, the selection process will expand to all counties once the geoscience high school Leoben becomes the national selection center from 2016 onwards.

Potential participants then submitted written applications elaborating why they wanted to take part in the IESO selection phase. Pre-selected students underwent a two-day selection phase called *Talentecamp,* organized by Landesschulrat Carinthia. On day one, students were asked to do practical experiments and theoretical problems covering the entire range of geosciences. The county museum *Rudolfinum Carinthia* and resident geoscientist, Dr. Claudia Dojen, were in charge of that sophisticated and well-organized selection phase (Figs. 2.1-2.4).

Day two consisted of intense work on hydrosphere and atmosphere problems, again both practically and theoretically (Figs. 2.5-2.6). The scientist in charge was Dr. Michael Lukas, geographer and chemist at geoscience high school Leoben, Styria. The selection phase concluded with written and experimental exams, which allowed definitive selection of an appropriate national team (Figs. 2.7-2.9).

Figures 2.1-2.4 Geosphere selection phase with Dr. Claudia Dojen, Landesmuseum Rudolfinum Carinthia.

Figures 2.5-2.6 Selection phase for atmosphere and hydrosphere, with Dr. Michael Lukas, geoscience teacher at HTL Leoben.

Figure 2.7. IESO 2013 India. From left: Kerstin Kullnig, Tobias Jechtl, Naomi Lutskes at TU Graz.

Figure 2.8 IESO 2014 Spain. From left: Sabine Seidl, students: Katharina Lachner, Magdalena, Sara Roth, amRus. Mentor: Kirsten vonElverfeldt

Figure 2.9 IESO 2015 Brazil, Austria team. From left: Sabine Seidl; students: Christoph Gruber-Veit, Jasmine Pfeifer, Anna Rupp, Selina Lösch; mentor: Bernhard Sallay.

2.3.5 Preparation Process

After selection and nomination, students undergo rigorous preparations at national institutions spread out over the entire year prior to the competition. This preparation phase remains unchanged from 2016 onwards. Several Austrian universities, museums and other geoscientific institutions are involved in that preparation phase (Table 2.4).

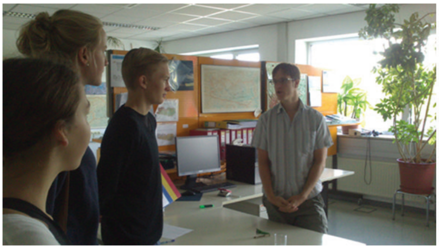
Tab 2.4 IESO scientific team. Institutions involved and responsible for scientific preparation of the IESO national team. Blue: hydrosphere and atmosphere content; green: geosphere content; red: astronomy content

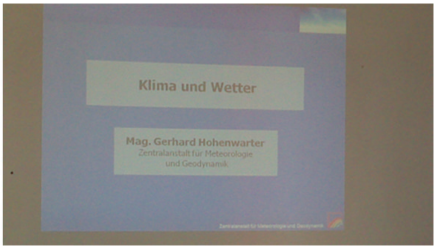
SCIENTIFIC INSTITUTIONS	COUNTY	SCIENTISTS IN CHARGE
Alpen Adria University Klagenfurt Department of Geography geo.aau.at	Carinthia	Dr. Kirsten vonElverfeldt
Astronomy Society Carinthia avk.at	Carinthia	Bernhard Sallay, MSc.

Geo-Center ERKUDOK Gmunden gmunden.ooe.gv.at	Upper Austria	Dr. Johann Weidinger
Landesmuseum Rudolfinum Kärnten landesmuseum.ktn.gv.at	Carinthia	Dr. Claudia Dojen
Technical University Graz Department of Geosciences tugraz.at	Styria	DI Gudrun Haage Elisabeth Uhlig, BSc. BSc. Kathrin Hollersbacher, BSc. Ao.Univ.-Prof. Dr. Dietmar Klammer
Natural Science Society Carinthia naturwissenschaft-ktn.at	Carinthia	Dr. Claudia Dojen
University College for Teacher Education Carinthia ph-kaernten.ac.at	Carinthia	Peter Holub, MSc. Sabine Seidl, MSc. Bernhard Sallay, MSc.
Regional Network for Natural Sciences and Mathematics Carinthia rnkaernten.at	Carinthia	Peter Holub, MSc.
Regional Network for Natural Sciences and Mathematics Styria imst.ac.at/rn_steiermark	Styria	Peter Holub, MSc.
ZAMG | Center for Meteorology and Geodynamics Austria zamg.ac.at	Carinthia	Christian Stefan, MSc. Gerhard Hohenwarter, MSc.

The IESO preparation comprised of theoretical lectures, interactive geoscience learning, as well as inquiry-based practical experiments (Figs. 2.10-2.18). Most of these lectures, seminars, pre-seminars and experimental laboratory work were based on former IESO tasks. Results were discussed in a group session. On average each institution worked an entire day with the national team:

Figures 2.10-2.11 Technical University Graz, Department of Geosciences.





Figures 2.12-2.13 Center for Meteorology and Geodynamics Austria, Klagenfurt Airport

Figures 2.14-2.15 ERKUDOK Geo-Center, Upper Austria

Figures 2.16-2.17 Alpen-Adria University Klagenfurt, Department of Geography and Regional Science

Figures 2.18 Astronomical observatory Klagenfurt

2.3.6 National Selection Center From 2016 Onwards

Dr. Michael Lukas, representing the geoscience high school in Leoben, Styria, is confirmed to coordinate the national IESO selection process to recruit potential students in the future. The goal is to recruit students from all nine Austrian counties to draw from a bigger selection pool. Further sponsorship and organizational support is accessed for this endeavor. The former selection structures such as *Talentecamp* will, however, be incorporated into the new system.

As for the preparation phase, all scientific institutions mentioned will remain key institutions once the national team is recruited. It took a lot of initiative and meetings to get this network of scientists together ensuring high quality training. At this point I want to thank the entire IESO scientific and organizational team once again for their dedicated and hard work. Last but not least, I have to thank Peter Holub who laid the project into my hands.

In conclusion, an increasing interest in geosciences is observed in Austria, especially with regard to sustainability, environmental and global issues. Geography teachers as well as other natural science teachers continue connecting the required curricula to cutting-edge geoscience topics, *i.e.* smart phone industry and resources such as Rare Earth Elements.

The bottom line is that IESO provides a network and a modern motor for a kaleidoscope of natural scientific projects and it has definitely become an inevitable platform in Austria for promoting Earth sciences.

2.3.7 Media 2013-2015

Austrian daily paper *kleinezeitung* online about IESO in Brazil 2015:
http://www.kleinezeitung.at/k/kaernten/kaerntnerdestages/4836478/Kaerntnerin-des-Tages_Anna-Rupp-ist-ein-echtes-Naturtalent

Weekly paper www.meinbezirk.at Sept 30, 2015:
http://www.htl.at/htlat/news/news.html?no_cache=1&tx_ttnews%5Btt_news%5D=27144&cHash=a15bcbfde265f258f0f88c55f1eec64c

High school for geosciences in Leoben, Styria, school homepage:
http://www.htl.at/htlat/news/news.html?no_cache=1&tx_ttnews%5Btt_news%5D=27144&cHash=a15bcbfde265f258f0f88c55f1eec64c

Website of the Education authority Carinthia 2013 to 2015. Governor of Carinthia, Dr. Peter Kaiser, honoring the IESO national teams:
http://www.meinbezirk.at/klagenfurt/lokales/kaerntner-nachwuchs-naturwissenschaftler-raeumten-ab-d704892.html
http://www.mein-klagenfurt.at/aktuelle-pressemeldungen/pressemeldungen-september-2015/kaerntner-schuelerin-holte-gold-bei-ieso-in-brasilien/

Online platform Alpen-Adria University Klagenfurt:
https://www.facebook.com/geographie.klagenfurt/photos/a.251434741567480.62920.250094325034855/619688778075406/?type=3&theater

Geo-Center ERKUDOK, Upper Austria:
http://www.salzi.at/2013/09/erkudok-institut-als-trainingszentrum-fur-die-internationale-erdwissenschaftliche-olympiade-2013/

2.3.8 Print media

In all competition years print media provided wide coverage on Austria's participants and thus promoted geosciences in the public.

***

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www.bifie.at
www.schule.at
www.ieso-info.org
www.talentecamp.at
htl-leoben.at

Sabine Seidl

Sabine Seidl, MSc. (*1974, female) received her Masters of Science Degree in Chemistry from Karl Franzens University Graz, Austria in 2001. From fall 2000 to spring 2001 she worked at the University of California San Diego School of Medicine for her Master's Thesis in the realm of biochemical medicine. After that, she taught Chemistry and English in Austria until the present. From 2009 onwards, she was a chemistry mentor for the European Union Science Olympiad (EUSO), responsible for the entire national training since 2012. She successfully participated in EUSOs all over Europe. Since 2012, besides teaching her subjects, she has also worked at the University College of Teacher Education (UCTE), with responsibilities for chemistry teacher trainings. Next she launched Austria's participation in the International Earth Science Olympiad (IESO) landing financial, infrastructural and scientific partner institutions nationwide. In 2015, Austria hosted the EUSO in Klagenfurt where she, together with Christina Morgenstern and others, represented the core executive organizational team. Also in 2015, she was nominated for her teacher training project "A journey into the depths of a smartphone" at the Science on Stage Festival in London. The project focuses on exploring the chemistry of smartphone components including addiction, problematic compounds, exploitation of cobalt mining countries, and recycling. She now offers this project at UCTE. *University College of Teacher Education Carinthia Viktor Frankl Hochschule. Hubertusstrasse 1, A-9020 Klagenfurt, Austria, +43 699 107 44 199. E-mail: sabine.seidl@ph-kaernten.ac.at*

Chapter 3

The System of National Selection and Student Preparation for IESO in the Republic of Belarus

Nadezhda Ganushchenko, Iryna Vlodavskaya, Ludmila Shkel, Henryk Oziem, Liudmila Fakeyeva, Alexander Zarubov

Abstract

This article considers the Republic of Belarus's national selection process for participation in the International Earth Science Olympiad (IESO). The main foci of preparation for participation in the IESO are forming spatial reasoning skills and process knowledge, developing the ability to apply knowledge in practice, and gaining experience using skills in different situations. The main goal fostering students' general ideas and knowledge about the spatial peculiarities of geographic patterns of the geosphere, hydrosphere, atmosphere, and biosphere. Participation experience shows the advantages and disadvantages of our general secondary education system for training students.

Keywords: Geosphere of the Earth, Man and the World, Geography, Physics, Astronomy

3.1 Introduction

The current procedural instructions for the national academic subject Olympiads determine the organization and conduct of the Geography Olympiad for students and training Belarusian teams to participate in international competitions[1].

The main goals for preparing students to participate in international

1. Resolution of the Ministry of Education of the Republic of Belarus 20.11.2003 N 73 (as worded by resolution of the Ministry of Education dd 13.09.2011, and 05.08.2014).

competitions are the following: to raise students' interest in studying Earth sciences; to develop their creative abilities, deepen their theoretical knowledge and practical skills, and promote their self-realization; prepare gifted students to continue their studies in institutions of higher education; to encourage teachers to develop the abilities of gifted students; to revitalize the work of interested associations; to entice researchers, teaching staff, and graduate students to assist with educating and organizing students; and to promote scientific understanding and develop students' interest in science.

3.2 National selection process

In Belarus, the Olympiad progresses through four stages each academic year:

First stage – educational institutions;
Second stage – district (city);
Third stage – regional (Minsk city);
Fourth stage – final (national).

Each step of the Olympiad includes a theoretical, project/practical (field and laboratory stages), and multimedia component specific to Geography. Any participant of the final stage can participate in an additional component in English, which includes a theoretical part and an interview.

At each stage of the Olympiad, a jury determines the winners from among the members of the relevant stage. One team from each region and the city of Minsk takes part in the final stage. Only the winners of the third step are included into the team of no more than 15 people.

The jury for the final stage of the national Olympiad determines the Republic of Belarus team members who will participate in the International Earth Science Olympiad (IESO). The National Institute of Education at the Ministry of Education of the Republic of Belarus organizes and conducts training camps for the team's candidates. In particular, it provides accommodation, meals and training for participants while preparing for the IESO according to the schedule for the team of the Republic of Belarus. Most of the subject instruction at the training camp is given by teachers from higher educational institutions in Belarus, in particular the Belarusian State University. The Belarusian Geographic Society, a Non-Government Organization, is also involved in preparing and motivating students.

3.3 Students' preparation for IESO

The main emphases during training for participation in the IESO are on developing an understanding of spatial relations and processes, developing the ability to apply practical knowledge, and gaining experience applying practical skills in different situations. The overarching goal of the training is to form students' general ideas and background knowledge of the particular expressions of geographic patterns within the geosphere, hydrosphere, atmosphere, and biosphere.

The ancillary goals of training are: developing sufficient knowledge to perform practical work and deal with a variety of instruments and equipment; improving abilities to use various sources of information about geographic objects and phenomena, to work from books, educational mapping publications, reference materials, study materials, electronic and other information sources; to solve simple everyday tasks, as well as qualitative graphic and design problems; gaining practical skills to navigate the terrain, calculate distances using scales, determine geographic coordinates using a grid, and communicating the results; developing skills to characterize physical and geographical features, to recognize common and distinctive landforms; cultivating the ability to understand the essence of geo-ecological problems of the geo-biosphere, their manifestation patterns and propose possible solutions at global, regional and local levels; to establish the ability to distinguish geographical aspects of global models, and generate strategies for sustainable development for mankind and the Republic of Belarus.

3.4 Teaching Earth Sciences in the Republic of Belarus

The geographic patterns manifested in the Earth's spheres (geosphere, hydrosphere, atmosphere, lithosphere, and biosphere) are studied within such subjects as "Man and the World", Geography, Physics, and Astronomy. Four comprehensive blocks: geology, meteorology, oceanography, and astronomy are also studied by students.

In 2016-2017, a model curriculum was applied to determine the number of hours for students to study academic subjects. In 2015 the curriculum underwent its annual review and approval process, to determine its capacity to fulfill the basic education requirements (Table 3.1).

Tab. 3.1 The number of study hours for subjects [2]

Subject	**Man and the world**	**Geography**	**Physics**	**Astronomy**
Number of hours/ year/ week	*V grade,* *35 / 1*	*VI grade*, 35 / 1 *VII grade*, 35 / 1 *VIII grade* , 70 / 2 *IX grade*, 35 / 1 *X grade*: Basic level, 70 / 2, Advanced level, 105 / 3 *XI grade*: Basic level, 70 / 2, Advanced level, 105 / 3	*VII grade*, 70 / 2 *VIII grade*, 70 / 2 *IX grade*, 35 / 1 *X grade*: Basic level, 70 / 2, Advanced level, 140 / 4 *XI grade*: Basic level, 70 / 2, Advanced level, 140 / 4	*XI grade*: Basic level, 35 / 1, Advanced level, 70 / 2

The secondary education system of the Republic of Belarus provides basic education aimed at the ethic, moral, and physical development of the individual student. It is designed to prepare him for a full life in society by mastering the basics of Earth sciences, honing mental and physical labor skills, forming moral beliefs, and engaging in lifelong learning.

The general secondary education is comprised of three stages:

I stage – elementary education (I-IV grades);

II stage – basic education (V-IX grades);

III stage – secondary education (X-XI grades; in extension school – X-XII grades, night classes – X-XII grades).

The I and II stages of general secondary education make up the fundamental education which fulfills the basic education requirements.[3]

The general nature of the Earth is studied at elementary school (I stage) within the subject lessons of "Man and the World". The focus of the subject is to form an initial understanding of the Earth's inherent attributes. The concept of individual environmental education provides the basis for its content. The principal ecology teachings are about the interconnectedness of nature in the greater context of the Earth as a whole.

At the V grade (II stage) the curriculum is focused on preliminary instruction to provide an grounding in the basics of Geography, Biology, and Physics. The content includes three Earth science themes: "The Earth and the Universe", "How People Discovered the Earth" and "The Nature of the Earth".

2. Resolution of the Ministry of Education of the Republic of Belarus dd 12.04.2016 nº 24
3. Code of Education of the Republic of Belarus

While studying the subject, students are introduced to theoretical and empirical evidence about the universe, celestial bodies of the solar system, the place of planet Earth in the universe, and the movement and rotation of the Earth. Due to the fact that Astronomy is studied only at the XI grade, “Man and the World” is not an introduction to astronomy.

The structure of the section “Nature of the Earth” is a component-based approach to learning. It aims to form students’ holistic view of the nature of the Earth while studying its component spheres (atmosphere, hydrosphere, geosphere, and biosphere). Developing students’ empirical knowledge of the planet through personal experience and practice is the prevailing pedagogy. The section includes 12 different observations of phenomena and objects of nature and one excursion.

At the V grade students learn to find stars and constellations on the atlas map and in the sky. They watch the position of the Sun change in the sky, observe sunrise and sunset, mark the apparent motion of the sun across the sky, and determine the phase of the Moon. They examine differences between various geologic samples including chalk, sand, granite, and salt. They also learn to work with a geographical map.

The study of Geography aims to develop students understanding of objects of nature, Earth processes and phenomena, plus geo-spatial features and their manifestations at local, regional and global levels.

Innovative key approaches to content delivery in Geography are:

- Using an integrated geographical approach, which takes into account logical interrelationships and interdependence of natural, social, economic and political structures, phenomena and processes in the analysis of any region (*e.g.* a small local area, country, group of countries, continent, or entire geographical environment);
- Taking a system-activity approach, represented by three components: knowledge (comprehension), practical (skills), and operational (abilities);
- Developing students’ professional competence via basic geographic knowledge and practical skills application, which has relevance in their lives and future careers;
- Adopting a cultural (value-oriented) approach, which allows students to consider the geographic environment in light of human achievements; it aims to develop spirituality, morality and humanistic qualities of individual students.
- Emphasizing professional competencies and system-activity ap-

proaches to keep students motivated to acquire the basic knowledge and skills that form the foundation of a geographical and cultural world view, encouraging them to think geographically and consider geography as one of the pillars of everyday life.

3.5 II level - basic education (V-IX grades)

In connection with the step by step implementation (from the 2015-2016 school year) of the basic education requirements at the II stage, the study of geography is different in target settings, content, forms and methods of organizing the learning process.

The key idea of the current geographical curriculum forms a basic model for a didactic process aimed at stimulating students' cognitive activity by including students in the educational process through reflective practices. Involving students in debating the basis for understanding a variety of vitally important practical situations and the development and promotion of their reasoning capacity, to defend their view point without conflict. The content is a single system of interconnected components that ensure the continuity of the content, forms and methods of student learning activities:

- Geography: Physical Geography (Grade VI);
- Geography: The continents and oceans (Grade VII);
- Geography: Countries and peoples (Grade VIII);
- Geography: Geography of Belarus (Grade IX).

At the VI grade the study of geography becomes an independent academic subject, but students get necessary background knowledge at elementary school and in the lessons of "Man and the world" at the V grade.

Physical geography's main goal is to provide a view of the world as a large natural complex, its structure, and the relationship of the Earth's spheres (lithosphere, atmosphere, hydrosphere, and biosphere). The formation of key competencies is based on a system-activity learning approach.

The main purpose of studying continents and oceans is to form a geographic world view, through which students' geographic thinking develops. Introducing comprehensive information about natural features on our planet and separate regions provides the foundations for a sense of personal responsibility for the current and future state of the environment as a part of the planet Earth.

At VI-VII grades students learn to read maps and the landscape (to define objects by conventional signs, the parties of the horizon, azimuth, altitude, relative altitude, directions, distances, and their relative positions), to use a compass, to determine geographical coordinates and directions, to use a thermometer, barometer. The Geography of Belarus forms the students' integral geographical view of their country. Students study natural conditions and resources, ecological features of the country's natural and economic potential.

At the IX grade students learn to draw and analyze climate charts, graphs, and wind rose diagrams for the nearest meteorological station. They calculate the dew point, the amplitude of the annual temperature, and slope and discharge of river systems. They learn how to plot climatic parameters diagrams and to use mapping skills.

3.6 III level - secondary education (X-XI grade)

Due to the introduction in the 2015-2016 school year of Field Specific Education at the secondary education III stage, the study of geography at X and XI grades is organized into two levels: basic and advanced. The levels differ in their learning outcomes, number of subject study hours, content, forms, and learning methods. The curriculum comprises a single system of interconnected components to ensure continuity of content, forms, and learning activity delivery methods.

"Global Problems of Humanity" is the culminating section of geographical education that integrates geographic understanding to analyze the interaction and interdependence of the environment and humans, spatial and temporal regularities of their dynamics and evolution, and knowledge of the territorial organizational laws of nature and human society.

3.7 Physics Studies

The focus of Physics is on understanding material structures, the basic laws of mechanical motion, conservation and transformation of energy, the laws of heat, light and electromagnetic phenomena (VII-IX grades); the basic laws of electrodynamics, thermodynamics, and statistical, quantum and nuclear physics (X-XI grades). Important components of these courses are: developing the ability to apply knowledge to explain natural phenomena, processes, and physical properties of substances; the practical application of physical knowledge in everyday life; understanding the role of physics in developing modern technologies to solve critical problems facing humanity, and in creating conditions for safe human life and society. Forming students' skills for solving key practical tasks using physics principles in the areas of environmental management and protection, and human health and safety is an important part of the content.

The mandatory curriculum content required at each level of preparation are summarized as: physical methods for natural phenomena investigation; physical objects and interaction patterns between them; physical aspects of human life.

At VII grade students practice: making measurements using instruments and discipline specific equipment (*e.g.* ruler, tape measure, measuring glass/cylinder, stopwatch, thermometer, scales); determining scale intervals and measurement limits; measuring the distance, size and mass of bodies, areas, volumes of liquids and solids of different shapes and vessel capacity, time, and temperature; determining substance density using the relationship between volume and mass; measuring the average speed of uneven body motion and frictional forces; graduating a spring dynamometer; using devices (barometers and manometers) to measure pressure; and expressing measurement results in SI units and millimeters of mercury.

At the VIII grade students use devices (thermometer, calorimeter) to measure physical quantities: temperature, heat quantity, specific heat. They also solve simple everyday tasks such as: calculating the cost of electricity consumed by household appliances to find ways to save electricity, assessing the current strength in connecting wires when heaters are on, and meeting safety standards when using electrical appliances.

At IX-X grades students learn to solve qualitative, graphical and design problems, and evaluate the relationship between a vehicle's velocity and stopping distance. They explore electricity and magnetism using multifunction electrical measuring devices to measure EMF and internal resistance, depict the magnetic field graphically, and determine the direction of the magnetic field, Ampere and Lorentz forces.

3.7 Astronomy Studies

Astronomy draws on the most fundamental laws of nature, which form the basis for the Science education curriculum, necessitating an interconnection between teaching astronomy, physics, geography, chemistry, biology, and mathematics. The main difficulty in preparing students for the IESO is the fact that Astronomy is only formally introduced as a stand-alone subject at the XI grade.

The study of astronomy allows students to apply their analytical skills gained through their physics and mathematical preparation by using almost all of the concepts and laws studied in these other academic subjects. Since astronomy is studied in the final stage of education, it is impossible to base work in this subject on students' prior knowledge while training for the IESO. Numerous skills required for the IESO are only acquired by students at the XI grade, such as: determining the visibility of stars (constellations), the Sun, or the Moon on a given date and time via a mobile star chart; finding the brightest stars (*e.g.* Sirius, Arcturus, Vega, Antares, Betelgeuse, Rigel, the North Star, etc.) and constellations in the sky; using a star chart to read the coordinates of stars and indicating the position of the celestial object using the given coordinates; solving problems using the relationships between the latitude of the observation site with the celestial body's azimuth; having practical skills to orientate within the terrain via the sun, moon and stars; solving problems using formulae linking the synodic and sidereal periods of planets, Kepler's laws and the universal law of gravitation; and applying practical skills working with small optical telescopes. This is a serious drawback of the system.

3.8 Conclusion

Students begin studying the Earth's spheres in the V grade with an introduction to geology, meteorology, oceanography, and astronomy. The essentials of objects and phenomena of nature, the universe, its structure, features of the motion and rotation of the Earth are included in the V class studies. At the VI grade, the concept of the geosphere is introduced and its components are studied at theoretical and empirical levels of individual continents and countries. The study of physics begins at the VII grade. The content of the subject logically fits into the system of students' previously acquired knowledge and skills. Astronomy knowledge, which is necessary to participate in the IESO, is only introduced at the XI grade, which is a serious drawback. Therefore, teachers in the training camp approach the necessary knowledge and skills in this field with almost no reliance on previous learning. The experience of the Republic of Belarus teams in IESO has shown that the student selection system and their further training is rather effective. Over previous years, Belarus has been rather successful in this competition. However, it should be noted that participants representing the Republic of Belarus at future international competitions can strive for improvements on certain points.

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Chapter 4

Teaching Earth Sciences in Brazil

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Abstract

Teaching in Brazil was restructured after the end of the military dictatorship in the 1980s. Previously, teaching that had a professional line secured by law, came to be treated as scientific, technological, philosophical and artistic. Now Earth Sciences are taught from the first stage of elementary school, when it is encompassed within the discipline of science, followed by second phase of elementary school, when it becomes more specific within Geography and other interdisciplinary areas. Finally, in high school the same subjects are approached in greater depth. High school may be integrated into technical education. For example, the Federal Institute of Education, Science and Technology, from South of Minas Gerais State, Campus Inconfidentes offers high school integrated with technical courses, such as Agricultural and Surveying, which have a direct focus on Earth Sciences, both in high school and in technical education, focusing on the origin and formation of soils, organic matter, fertility, etc. In addition to the integrated technical courses, they also offer undergraduate courses in Agricultural Engineering, Degrees in Biological Sciences, Surveying and Cartography Engineering, Environmental Engineering, Environmental Management, etc. that incorporate work topics directly related to Earth Sciences curriculum. Earth sciences are taught in Brazil using an interconnected approach, recognizing that the interdisciplinary nature of these activities. Earth Sciences topics are treated comprehensively and, at the same time, specifically within each of the disciplines that involve basic, technical or undergraduate student training.

Keywords: Brazil; Earth Science Teaching; Technical High School Integrated.

4.1 Teaching of Earth Sciences in Brazilian schools: A brief national history

In Brazil, education has always been a prominent theme in every government. The transition from military dictatorship to civilian democracy, brought to education some modifications that came naturally. The social movements in Brazil during the 1980s were very important to the proposed educational changes, which contributed to the draft of the new Brazilian Constitution (BRAZIL, 1988). This action clarified that education is a social right of citizens. As Brazil is a federation of States, the Union's responsibility is related to the guidelines and bases of education, and the State along with the family, are responsible to encourage the cooperation of society, seeking development the total person, their preparation for the exercise of citizenship and their qualification for work.

The professional courses under the Brazilian Law of National Education Guidelines and Bases from 1971 (LDBEN No 5692/71), that aimed to unify the old primary and secondary education, eliminating the differences among the agricultural, industrial, commercial and regular areas, were gradually being replaced by high school "science", resulting in contents changing from strictly technical to more scientific, technological, philosophical, and artistic.

To ensure a minimum standard of quality and equity in education, the Guidelines and Bases National Education Law was enacted (LDBEN No. 9.394 / 96), adopted on December 20th, 1996, which consolidates and extends the government's duty to education. This law reinforces, among other demands, the need to provide a common basic education to all students.

The law 13.415 / 2017 proposed some changes in the Law No. 9.394 / 96, one of them being the change in the rights and objectives of secondary education, following the areas of knowledge: I - languages and their technologies; II - mathematics and its technologies; III - natural sciences and their technologies; IV - applied human and social sciences. It is noteworthy that Law 9394/96 has other changes, however this chapter does not pretend to exhaust the possibilities of reading and analysis of laws.

The content for this basic training was outlined in the National Curriculum Parameters (PCNs in Portuguese), which presupposed the formulation of guidelines for the curriculum and their minimum content. In addition to the PCN, the LDBEN indicated that a more precise definition of the basic content would occur in the National Education Plan (PNE in Portuguese). This was accompanied by an assessment proposal to assess whether those goals were being met. This review is an integral part of the first PNE 2001 (Law 10.172 / 01), which officially aims to promote institutional management efficiency through curriculum revision and competitiveness triggered by an external evaluation process.

In Brazil, the free education guaranteed by the current legislation is divided between primary and secondary education. Elementary school is divided into two stages, the first encompassing the 1st to 5th years after the pre-school, and the second for 6th to 9th grade. From the second stage of elementary school, disciplines are taught by specialist teachers in different core subjects addressed, proceeding this way until the end of high school, that constitutes the final three-year period. Additionally, there is also high school integrated into technical education, where there is additional vocational training, which allows students to prepare for professional work in several areas. Following on from this, we address the means and peculiarities of how Earth Sciences are approached in elementary and high schools in Brazil.

The science teaching is inserted into a continuous historical, social and cultural process context, in which the knowledge gained makes sense for students as they contribute effectively to understand, explain and intervene in the world in which they live. Thus, “Earth Sciences” content is included in the “Natural Sciences”, as addressed in elementary schools, and it is treated in an interdisciplinary way in all knowledge areas, hence it is a transversal theme. Moreover, this area that is broadly called “Science” in high schools, is distributed into Biology, Physics, Geography, and Chemistry curricular components. (BNCC, 2015b).

For the initial elementary school years (1st to 5th grade), education is generally provided by a single teacher with a undergraduate degree, preferably in Education. In the elementary school second stage (6th to 9th grade) and high school, due to the interdisciplinarity of the content, natural sciences disciplines require teachers trained for this purpose. These teachers should have specific training involving undergraduate courses, such as biology, chemistry, geography, and physics. In absence of qualified teachers, it is possible to consider those with backgrounds such as Pharmacy, Physiotherapy, Medicine, among others courses with a sufficient sciences component in their curriculum.

Currently the school curriculum of Minas Gerais State follows the Common Basic Contents guidelines (CBC in Portuguese), which were implemented in public schools of Minas Gerais since 2005, by Resolution from the State Education Secretary (SEE, in Portuguese) and No. 666 of April 7, 2005. Officially, CBC’s function is to provide a minimum basic content to students, regardless of the region where the school is located. As well as the PCNs of the Ministry of Education (MEC in Portuguese), the CBC provides access to established knowledge and recognized expertise that are necessary for all citizens.

In the early elementary school years, content is treated using an interdisciplinary approach, allowing issues related to Earth Sciences to be integrated into geography, science, and history. The content covered in these disciplines is established in accordance with the CBC using a comprehensive approach at this stage, initially through concepts introduction, followed by deepening then consolidation. The science discipline thematic areas are: Environment and Life; Human Health and Body; Earth and Universe; Technology and Society. Geography themes included are: Everyday Geography; Cartography; The Nature and Dynamics: Natural and Cultural Landscape; Means of Movement: Transportation and Communication; The Minas Gerais State in the Brazilian Territory. Finally, the lines in the history of the disciplines include: Historical Subject; Life in Society; Historical Time; Historical Source.

Earth Science content is worked into geography during the final years of primary school, in accordance to the CBC, through the themes: Geographies of Everyday Life; Sociodiversity of the Landscapes and its Spatial-Cultural Manifestations; Globalization and Regionalization in the Modern World; Environmental and Planetary Citizenship. In the Science disciplines, the working themes are: Environment and Life, Human Body and Health; Building Designs. In History, the working subjects are: Life Stories, Population Diversity and Migration; Construction of Brazil: Territory, State and Nation; Nation, Work and Citizenship in Brazil.

The Earth Science content offered in Brazilian high schools is encompassed within Geography. The themes, according to the CBC are: Urban Problems and Prospects; Rural World Changes; Natural World Mutations; Globalization and Fragmentation Scenarios. Some topics are also included in Biology in subjects such as Energy and Biodiversity, and in Chemistry in subjects such as Material Properties; Materials Constitution and Organization, and Energy Involved in Material Transformations.

In 2015 the Brazilian Federal Government along with the Ministry of Education designated the Common National Base Curriculum Project (BNCC in Portuguese), which involves the construction of students' knowledge and basic skills for further studies in all Brazilian schools. The implementation of this project aims to improve the teaching-learning process. It was proposed after examining the need for a common curriculum through the results of large-scale assessments proposed by LDBEN and

PNE, promulgated in 2014, by Law 13005 / 2014, which reiterates the need to preserve learning rights and objectives and students for each year of Elementary and High School, respecting regional, state and local diversity.

The BNCC officially ensures that the objectives provided by law, along with the students' requisite foundations are effectively met by schools through a common curriculum, so all students have knowledge based on the same opportunities, reducing educational inequality. Therefore, students who transfer between educational units are not adversely affected and may continue their studies in any city, in any Brazilian state (BNCC, 2017).

The BNCC described a compulsory national curriculum for all Brazilian states. Specifically for teaching natural sciences, including the Earth Sciences, the essential learning aims of this curricular component were organized in three thematic units that are repeated throughout Elementary School: Matter and Energy; Life and Evolution; Earth and Universe. The last one is the theme that deepens the teaching of Earth Sciences as stated:

> "The students of the early years are easily interested in celestial objects, much because of the exploration and valuation of this subject by the media, toys, cartoons and children's books (...) The systematization of these observations and the proper use of systems of reference allow the identification of phenomena and regularities that have given humanity, in different cultures, greater autonomy in the regulation of agriculture, in the conquest of new spaces, in the construction of calendars, etc.
> In the final years, there is an emphasis on the study of soil, biogeochemical cycles, terrestrial spheres and interior of the planet, climate and its effects on Earth life, so that students can develop a more systemic view of the planet based on principles of social and environmental sustainability" (BNCC, 2017, page 326).

In accordance with BNCC, Geographical reasoning will favor exercising spatial thinking, as it applies principles to understand fundamental aspects of reality: the location and distribution of facts and phenomena on the Earth's surface, territorial ordering, and existing connections between natural-physical and anthropogenic actions (BNCC 2017, page 357). It is worth mentioning that it will encompass five thematic units: the subject and his/her place in the world; connections and scales; world of work; forms of representation and spatial thinking; nature, environments and life quality.

Therefore, in Brazil, knowledge acquisition and development of attitudes and values grows from interdisciplinary teaching, incorporating all areas of knowledge.

4.2 Teaching Earth Sciences in IFSULDEMINAS – *Campus* Inconfidentes

Earth Sciences teaching at the Federal Institute of Education, Science and Technology from South of Minas Gerais State, Inconfidentes *Campus* (IFSULDEMINAS - *Campus* Inconfidentes) is presented here as an example. IFSULDEMINAS is a high school integrated into full-time technical teaching college, with professionals training in Agriculture, Surveying, Computer Science, and Food Science, as well as undergraduate courses in Agricultural Engineering, Surveying and Cartographic Engineering, Food Engineering, Degree in Biological Sciences and Mathematics, Environmental Management Technology and Computer Networks. The Inconfidentes *Campus* also offers general post-graduate degrees in Early Childhood Education and Environmental Management.

The Inconfidentes *Campus* has as mission to promote excellence in vocational and technological education, at all levels, forming critically thinking, creative, competent and humanist citizens, coordinating teaching, research and extension, contributing to the sustainable development of the South of Minas Gerais State. In this sense, the Inconfidentes *Campus* uses integrated methods for Earth Sciences (or Geosciences) teaching, encompassing different disciplines.

The IFSULDEMINAS - Inconfidentes *Campus* is based on provisions of the Law of Directives and Bases of Brazilian Education (LDBEN No. 9.394 / 96 and alterations), and complemented in the changes introduced by the Law nº 11.741 / 2008 (BRASIL, 2008). The Campus offers technical courses integrated in modulation to high school as the final phase of students' basic training and preparation for the work force and/or further study. Earth Sciences teaching in high school cross cuts multiple disciplines, such as biology, geography, chemistry, physics, mathematics, history, sociology, and others. Through this technical education, we show that almost all disciplines within the Sciences are included within the Earth Sciences, such as the Technical Course in Agriculture Integrated to High School or Technical Course in Environment. The integrated technical courses show the possibility for promoting the fundamental formation of the person, precisely because it allows a holistic view of technical and humanistic knowledge.

Earth Science content is widely spread across the diff erent schools levels. For secondary schools, it is important to mention the schools that have special programs with additional schools hours. Ifsuldeminas is an example of this kind of school, which is characterized by the wide range of laboratory facilities and tools instructors may use for practical activities with students. These additional learning provisions support students' preparations to become good professionals in their field of expertise or continue their learning at university level.

It is worth mentioning that are many projects of teaching, research, extension and innovation focused on Earth Sciences, providing human resources with the applicability of sustainable techniques, focusing on the quality of life. There are also several national actions implemented in parallel to promote teaching and learning in this area of the scientific olympiads, such as the Brazilian Agricultural Olympiad (OBAP), the Brazilian Olympiad of Earth Sciences (OBCT) with the Brazilian Geography Olympiad, the Geo-Brasil Olympiad (OGB), Olympiad of Knowledge, among others, within which IFSULDEMINAS participates effectively whenever possible.

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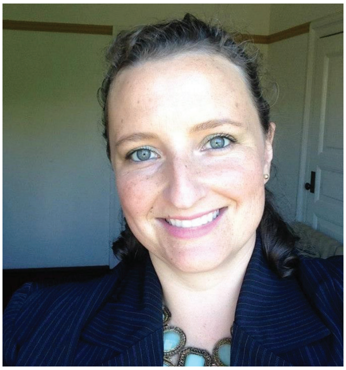

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Chapter 5

The State of Natural Sciences Education in Bulgaria

Philip Machev

Abstract

Natural sciences education (mostly geography) in Bulgaria began when Bulgaria was part of Ottoman Empire. Thus, we identify several historical stages according to their periods of Bulgarian society development, namely: Bulgarian national revival, post-liberation, socialist, and present day. The downside of the current period is the reduction of school hours and subject name change from Geography to Geography and Economics. The status of geology education is even direr. Up until the 1964/1965 school year, geology was compulsory in junior high school courses, but was then removed with the argument that geography textbooks provide the necessary geology knowledge.

Key words: geography, education, Bulgaria, Earth Science

5.1 Natural sciences education in Bulgaria

Natural sciences education in Bulgaria depends directly on the political, economical and social processes in its society. Analysis of the education system is thus determined by development of Bulgarian socio-economic systems. On this basis, Tzankova (2013) identify four periods.

5.2 Bulgarian National revival period

This period is distinguished by: an economic rise; national revival and realization; development of trade relations and crafts, and appearance of the bourgeoisie; foundation of the Bulgarian education and learning system; and appearance of the first schools.

During this period, the subject geography is included at the first school in the town of Gabrovo, as a result of society's need for geographic knowledge of foreign countries, roads, trades, and resources. The textbook of Fotinov (1843) defines the goals of geography as developing the ability to describe the Earth and gain knowledge of Earth's surface and political life. Publishing this textbook during the Bulgarian National revival is a remarkable achievement. The first syllabus, which defines the subject content, is also developed at this time. Through the textbook and syllabus, geographic knowledge is converted into an element of national pride and patriotic education.

5.3 Post-liberation period (1878-1944)

This period is characterized by significant changes in the country's economic and cultural development. Education was centralized in the Ministry of Education, yet the revival traditions of free and compulsory education remained. Geography became a primary subject in Bulgarian schools, with study hours ranging from 10-14 hours per week over the whole high school course (2-3 hours per week during each school year).

5.4 Socialistic period (1944-1989)

Geography education during this period is characterized by several changes in the program scope and content, along with overall decreasing study hours, from 14 hours in the mid-1950s, to 10 hours in the mid-1970s, and finally to 11 hours at the end of the 1980s. Since the mid-1970s, geography is no longer included in the 11th and 12th year programs. Decreasing the school hours is unfounded as geography is the only subject delving into both geographic and economic understanding and skills. Nevertheless, two separate branches, physical and economic geography, were established during this education period.

During this period, geology was a compulsory subject in junior high school along with geography. Unfortunately, since the 1964/1965 school year, geology is removed based on the argument that physical geography sections in the geography textbooks provided the necessary geology content.

5.5 The present day (post-1989)

Is characterized by significant socio-economic changes, incorporation of Bulgaria into various European programs, along with NATO and EU membership. The significant political system changes yielded education reforms, including aspirations to achieve high quality education and the introduction of modern technologies. A new law for national education introduced state education requirements and three kinds of schooling, compulsory, compulsory-chosen, and optional, in 1991.

The period is marked by issues due to a steady decrease in compulsory geography hours, and furthermore compounded by splitting the subject from Geography into Geography and Economics. This created difficulties in the education process, as testified by the results from geography state school-exit examinations in 2009/2010, with average grades of 3.39 (on a scale from 1 to 6).

The natural sciences are not taught as a particular subject, but rather are included in the following subjects: *Geography and Economics, Physics and Astronomy, Chemistry and Environmental Protection, Biology and Health Education* and *Man and Nature.* Natural science themes are included in the curriculum at various levels and classes as follows:

Elementary education

Man and Nature (IVth class) – Planet Earth.

Junior secondary school

Man and Nature (Vth class) – Motion of luminous bodies in the Solar system; Temperature and heat; Transitions between states of bodies and matter; Air; Water and aqueous solutions.

Man and Nature (VIth class) – Significance and application of matter and chemical reaction (constituents of nature: atmosphere, hydrosphere, lithosphere; the human role in environmental protection and balance in nature).

Physics and Astronomy (VIIIth class) – Preservation of energy in heat processes.

Chemistry and Environment Protection (VIIIth class) – Chemical elements from VI A group (sources of acid rain and influence on animate and inanimate nature); organic substances (oil and gas, ecological problems).

Biology and Health Education (VIIIth class) – Lessons from section "Organisms – environment": Man and biosphere; human influence on the biosphere; protection of the atmosphere from pollution; pollution of the hydrosphere; protecting the hydrosphere from pollution; direct destruction of soils; protecting soils from direct destruction; human influence on natural ecosystems.

Geography and Economics (Vth class) – Earth: planet in the Solar system; Earth's setting; Earth's nature; Earth's natural resources.

Geography and Economics (VIth, VIIth и *VIIIth classes)* – The nature of continents and oceans.

Secondary education

Physics and Astronomy (IXth class) – Earth's magnetic field; magnetic storms; types of magnetic waves; seismic waves.

Chemistry and Environmental Protection (IXth class) – Nitrogen and carbon groups (diamond, graphite, influence of nitrogen and carbon oxides, ammonia, nitrogen acid, nitrates, phosphates, and cyanides, on humans and the environment).

Chemistry and Environmental Protection (Xth class) – Heat effects in chemical processes.

Biology and Health Education (IXth class) – Abiotic factors in the environment; the biosphere.

Biology and Health Education (Xth class) – Paleontological evidence for evolution.

Biology and Health Education (XIIth class) – Life environments: the hydrosphere as an environment for life; the pedosphere as an environment for life; the atmosphere and its influence on organisms; factors in environments; the biosphere's composition and boundaries; biomes; biogeochemical circles in the biosphere; anthropogenic influences on the biosphere and protection of natural resources; Man and the biosphere in the modern stage of Earth's development.

Geography and Economics (IXth class) – Earth's setting; natural components and Earth's complexes; natural global zones; global natural resource potentials; global problems – resources, energetic, and ecological; natural hazards; global problems of the modern world; global problems of the modern world and their occurrences by region.

Geography and Economics (Xth class) – Natural environments in Bulgaria; natural-geographic regions.

Geography and Economics (XIth class) – Interactions between natural and urban environments in urbanized territories; uses of nature; ecological problems.

Geography and Economics (XIth class) – The spatial diversity of the planet as a condition and factor of economic development.

The students obtain additional knowledge of natural sciences in Natural-Mathematic high schools.

Students' knowledge is tested by national school-exit examinations at the end of IV class, VII class, and XII class. There is a national geography Olympiad every year, through which winners can become University students without an entrance examination.

The education process is facilitated by teachers from various professional branches: the physical, chemical, and biological sciences, and educators thereof; history and archeology, and educators thereof; geography and economics; and natural sciences. Limitations of this educational approach are found in students' abilities to use experimental methods and limited theoretical knowledge. Whereas the advantages are their opportunities work on projects, and impressions of natural sciences, including: "Success", and "I love nature – and I participate".

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Chapter 6

Geo-education in Egypt between current and innovative

Kholoud Mohamed Abd El-Maksoud

Abstract

Geo-education term is still unknown in Egypt nowadays, the term Geology is not so common in the society, and also on the school student's level; Geology or geoscience as a term began to appear in the University Stage. Although the Egyptian syllabus contain few parts of geology but teachers and students don't know that this part is related to a science called Geology.

It was not easy to start dealing with this problem, how and by what means should we start to deal with the society what is Geo-education? How can we apply it? What is the impact of teaching students such science?

2012 was the beginning to draw a road map for geo-education in Egypt, visiting schools of different social levels, monitoring the student's level and finally creating a strategy for how we can teach this science in an interesting and innovative ways to achieve the best outcome. Application was not only on young aged students, but also on post graduate students on both genders (males and females).

Knowing the current level of geoscience education in Egypt enables us to start working on reality, and to enhance our performance in making geo-science more common as a science and as a term.

Key words: Geo-education, Education in Egypt, Geoscience Education.

6.1 Egypt's Education System

The education system in Egypt is divided into 4 stages: Primary (age 6 to 11 years), Preparatory (age 11 to 13 years), Secondary (age 14 to 16 years), and University starting from 17 years and ending at 20 or 22 years, according to the degree program.

Schools in Egypt are classified in to two main categories, governmental (public) and non-governmental (private) schools. More specifically, a school's classification depends on the social level of pupils, where the more affluent can send their children to private schools. There is, however, no difference in syllabus content (Abdel Maksoud et al., 2014).

Geology does not exist as a stand alone subject in the Egyptian syllabus except as an optional subject at the secondary stage. We discuss here geosciences in the curriculum at each stage:

Nothing regarding geoscience or geology has been detected at the Primary stage; the syllabus contains no information about the Earth.

In the Preparatory stage, we find the introduction of some information about Earth's structure, volcanoes, earthquakes, and geomorphology. The subject at this stage is not classified as geology, rather, it is taught under the guise of social science and/or geography. There is no mention of geology as science or connection drawn between information presented to students and geoscience.

In the Secondary stage, students are divided in to two section or are asked to choose either a scientific or literary stream. This selection qualifies the student to enter specific faculties at university. (For example, literary stream students are not qualified to study in the faculty of medicine or faculty of science). Geology as a subject offered at this stage, but only as an option for literary stream students, which means that who choose geology as a subject are not qualified to enter faculty of science to continue studying geology in university!

Only at the University stage are students who enter faculty of science able to study geology in detail. Geology also taught at an introductory level in the faculty of engineering.

6.2 Geoscience teaching in Egypt

Abdel Maksoud and others (2014) interviewed teachers to discover their teaching methods in schools. In each of the schools, there are four to eight science teachers; only three are allowed to teach geoscience. A total of 52% responded to the questionnaires (25 questionnaires collected). The questionnaire was designed to measure specific criteria such as knowledge of geoscience basics, importance of this science, delivery methods for this science (if present in the syllabus), and finally, the teacher's general knowledge. The questionnaire contained 15 questions structured to measure teacher's knowledge and awareness of current geologic events.

Five teachers (35% of participants) had good awareness and knowledge of geology, while nine (65%) were not familiar with geoscience and did not know whether or not geology is a science. Some teach the from the geology syllabus without knowing that fossils, volcanoes, and earthquakes are components this science. Others mentioned that, "we know about chemistry and physics, but geology is not a science." One of the teachers was honest enough to say that although she is a geology subject supervisor, she has no idea about geology or how to teach it. She further stated that she never gives the students real examples as she does not understand the subject. Additionally, the badly written syllabus makes the science uninteresting and difficult to understand.

This raises the very important question of who can teach geology in Egyptian schools and points towards one of the central problems. The fact is that geologists are not involved in planning geology education in Egypt, whereas geographers and chemists are allowed to teach geology. This is the default for many reasons, such as geology's absence from the syllabus as a separate subject until university and the general lack of recognition of geology's importance by society in Egypt.

Furthermore, it begs the question of how teachers in Egypt teach geology in the classroom. The majority use un-engaging and traditional (didactic) teaching methods, without field trips, illustrative figures, presentations or videos. Despite being written by geology professors, the syllabus contains incorrect and unbelievable geology content, which erodes this science's credibility in Egypt.

6.3 Weak Points in Geoscience Education in Egypt

We categorize the weaknesses into two main points: the education system and teachers.

Education system: handling geology and geosciences as though they are not important and have no meaning in our life is a fatal mistake in education. Discrimination of sciences is common in Egypt, where decision makers take engineers' opinions in building and neglect geologists' input regarding any potential geo-hazards. From this perspective, society places no value on creating a syllabus imbued with the importance of all science branches.

Teachers: Teachers are the main building block in the educational system; they can make any science interesting and understandable. If they are not sufficiently qualified to teach a particular subject, the system will fail in short course. In Egypt teachers are not qualified to teach geosciences, as mentioned previously, they have no background in geology, which creates a huge gap between students and the subject.

The two weaknesses are interrelated; fixing the first point depends on amending the second point and vice versa.

6.4 Strong Points in Geoscience Education in Egypt:

Our research indicates three strengths on which to draw for improving geoscience education in Egypt:

• Students are seen as a very strong starting point for education reform in Egypt, as they are very knowledgeable, both at public and private schools (Abdel Maksoud et al, 2014). Post graduate students are also able to understand and interact with geoscience. Hence, it is clear that there is a good basis of understanding, which could be a strong starting point from which to work (Abdel Maksoud, 2014).

• Egypt has many well qualified geologists who can train teachers to understand geology and how to teach this science to students.

• Parents in Egypt parents have a great desire for their children, especially females, to know everything. This could be leveraged as a means to motivate students to learn more about geology as an important and interesting science (if they were convinced of this).

6.5 What Happened in Geoscience Education from 2012 to 2016

Our investigation into geoscience education in Egypt began in 2012 with visits to nine schools in Cairo to determine the base knowledge level of students and teachers. In the same year, to develop a complete overview, a lecture was given to 30 selected 15-year old students to explain what geoscience is and how important it is. This lecture included one demonstration done by the lecturer using a puzzle for the continents to illustrate plate tectonic theory. The feedback from this lecture was very positive, with 98% of students expressing an interest in learning more about geoscience.

In 2013, we trialed different learning method approaches with 40 post graduate students ages 26 to 40. This investigation sought to determine what instruction methods are most effective for different age groups, but found out that we can use the same methods for all ages. The feedback from this trial feedback was also positive (Abdel Maksoud, 2014).

In 2014, as young geoscientists we established the ANGE (African Network for Geoedcation) to enhance the concept of geoeducation not only in Egypt but in all African countries. The Network has limited but effective activity, establishing itself in both Egypt and Morocco in less than two years and partnering at two international conferences.

In 2015, through the ANGE, the Academy of Science and Technology in Egypt and Cairo University hosted 200 students from age eight to 13 for a geo-activity day (Figs. 6.1, 6.2 and 6.3). The feedback from these activities was great with 60% of the students wanting to be a geologist after learning geology for only one day!!

In 2016, post graduate students (not studying geology) were asked to choose a geologic topic and to model it as a demonstration for school children. They chose seven topics (rocks, minerals, crystals, continental motions, geologic time, Earth structure, faults and folds) and created three effective and creative simulations. This was successful in engaging older students (with no geologic background) to interact with geology, by trying to simplify geologic topics for younger students (Figs. 6.4, 6.5 and 6.6).

6.6 Innovative Plan for Future Years

Believing in student capabilities is the main key for successful growth of geoscience education in Egypt. Our goal is to establish an association for geo-education in Egypt to train students and qualify teachers. This aim is not possible to achieve without first making the geology profession as commonly known as medicine or engineering.

Our plan for the coming years is to:

- Continue delivering outreach lectures for all ages, with special emphasis on students starting from age seven.
- Start writing a geologic booklet introducing geology in a simple way.
- Modify the syllabus found in the education system.
- Create new models and demonstrations using inexpensive materials to illustrate the fundamental ideas of the topic.

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Fig. 6.1 Students making paper volcano models using a resource downloaded from the Geologic Survey of London

Fig. 6.2 Students exploring volcanic eruptions using bicarbonate and vinegar after making their own models from clay

Fig. 6.3 Students creating their own dinosaur footprints

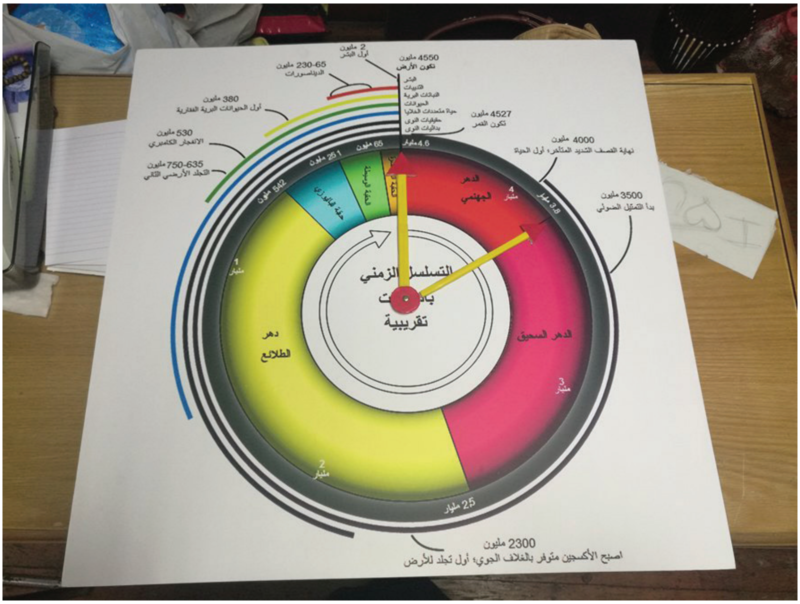

Fig. 6.4 An interactive illustration of the Geologic time sale as a clock, which allows students to think about deep time in terms of a single day

Fig. 6.5 An annotated model showing Earth's internal structure

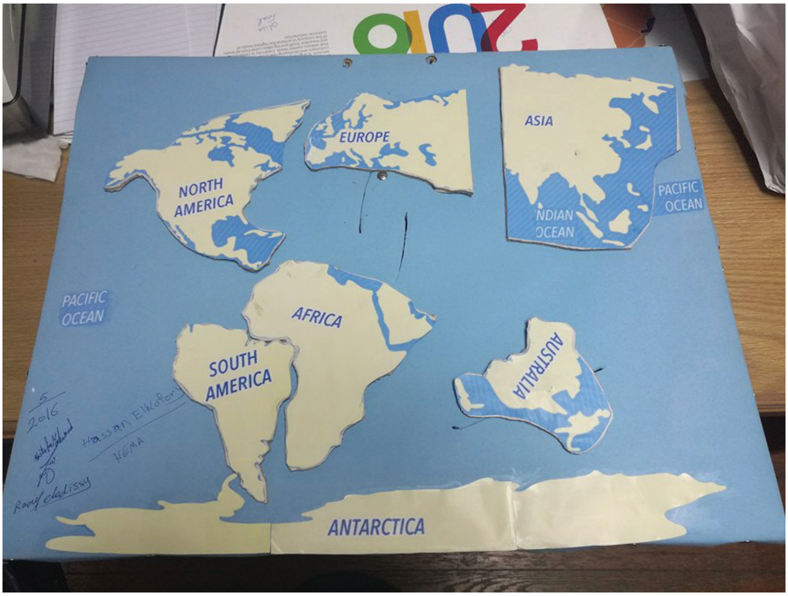

Fig. 6.6 An interactive model, where the continents are moved freely on the board, designed to illustrate the relative motion of continents required to form Gondwana and Pangaea

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Chapter 7

Earth Science Education in the Schools and Colleges of England

Chris King

Abstract

Earth science formed a small part of the English National Science Curriculum for 5-16 year old pupils during the past 25 years. It also comprises part of the English National Geography Curriculum, compulsory for 5-14 year olds. Optional geography examination courses containing some Earth science are taken by many 14-18 year old students, whilst optional geology examination courses are available to some 14-18 year olds.

Two initiatives, funded by the oil industry, support Earth science teachers. One offers free-of-charge professional development Earth science workshops to teachers and trainee (pre-service) primary (elementary) and secondary (high school) teachers of science and geography – reaching more than 37,000 individuals over the past 16 years, with excellent feedback and positive indicators of classroom change. The second initiative trained geology teachers through an intensive Summer School over the past two years, ensuring the supply of geology teachers into the future.

This relatively successful story is the result of dedicated hard work by a few individuals over many years, supported by some key organizations. The possibility of developing a national Earth Science Olympiad in the future to select candidates for the International Earth Science Olympiad (IESO) is under discussion.

Keywords: Earth science, geology, education, school, UK

7.1 Education in the UK

The National Curriculum was instigated in England, Wales and Northern Ireland, beginning in 1989. At that time, the new National Curriculum covered all three countries. Since then, first Northern Ireland and then Wales, separated from England. Hence, whilst the curricula in the three countries have the same roots they are now different from one another. Nevertheless, the same external examination system for 16 and 18 year olds still applies across all three countries, resulting in many similarities of teaching and learning. Despite this, the description below focuses mainly on education in England today.

Education in Scotland is historically different from that in England, Wales and Northern Ireland, with movement from elementary to high school occurring at different ages, and similarly from school/college to university. Scotland also has a distinct examination system from those in England and Wales. Therefore, the Scottish situation is largely omitted from the following discussion.

7.2 Education in England

Since the instigation of the National Curriculum in 1989, teaching in England is subdivided into Key Stages, with the school years shown in Table 7.1.

Tab. 7.1 Educational terminology and age-ranges in England

Key stage	Type of school/ institution		Ages in years	Designated school years	External examinations taken at end of phase
Key Stage 0	Nursery	Reception/ Early years	3-5		
Key Stage 1	Primary (equivalent to elementary schools in the USA)	Infant	5-7	1-2	
Key Stage 2		Junior	7-11	3-6	SATs (National curriculum tests) in English and Maths
Key Stage 3	Secondary (equivalent to high schools in the USA)	Lower secondary	11-14	7-9	
Key Stage 4		Upper secondary	14-16	10-11	GCSEs (General certificates of secondary education) in around eight to ten subjects
Post-16 (unofficially, Key Stage 5)	School sixth form or college		16-18 (or 19)	12-13	A Levels (Advanced levels) usually in four subjects
	University (3 year undergraduate courses)		18+		

The current National Curriculum (2016) comprises the core subjects of English, math, and science, along with the foundation subjects of modern foreign languages, history, geography, art and design, design and technology, physical education, computing and citizenship, whilst all government schools must also teach religious education. However, the 'National Curriculum' is not truly a curriculum applied nationally, as approximately 25 percent of schools have 'Academy' status, which excuses them from teaching much of the national curriculum. Similarly, no independent schools and none of the new free schools are obliged to follow the national curriculum either.

7.3 Earth Science Teaching in the UK Before 1989

Prior to 1989, Earth science teaching formed part of the geography curriculum, which was usually taught to most 5-14 years olds and was an optional subject for 14-18 year olds. School-level science was mostly taught as three separate subjects: biology, chemistry and physics, with no Earth science content. Geology was offered as a General Certificate of Secondary Education (GCSE) subject to some 14-16 year olds and as an A Level to 16-18 year olds in some schools, whilst Higher geology was offered to 17 year olds in some Scottish schools too. Most universities offered geology degrees within their science faculties.

7.4 Earth Science Teaching in England Beyond 1989

The new National Curriculum for Science, implemented in 1989, required all pupils to study science up to the age of 16, with most students studying science as part of 'double award science' (worth two GCSE subjects). This included biology, chemistry, physics and, for the first time, Earth science. Finally, with the introduction of this system, all students had to study a small amount of Earth science to the age of 16.

A strong memory remains of an Earth science workshop presented at the national Association for Science Education conference around 1989, when 20-30 attendees were expected and more than 120 people came, many of them standing on benches in the lab to find out what this new strange Earth science subject actually was. Because this was a 'new' subject to many science teachers, a special supplement of 'non-statutory guidance' was published by the government alongside the new curriculum, with a section devoted to this 'new' Earth science subject.

Since then, the National Curriculum for Science was re-organized several times and every time, Earth science educators have argued for maintaining the quantity and quality of the Earth science component. This attempted 'protection' of the Earth sciences often involved submitting materials against crazy deadlines and sending letters to government ministers. The result, depending on how the content is subdivided, is that Earth science remains as ~5-7 percent of the science curriculum. Sadly, in the latest revision, geological Earth science was removed from the KS4 science curriculum, despite all the efforts of the Earth science education community to retain it.

Earth science also remains as part of the geography curriculum, within the physical geography component. Unfortunately, this portion of the geography curriculum also varies, with human geography often seen as more important than physical geography.

The current Earth science content of the statutory National Curriculum is shown in Table 2.

Tab. 7.2 Earth science curriculum content – part of the statutory National Curriculum. (DFE, 2013 (Science KS1&2); DFE, 2013 (geography KS1&2); DFE, 2013 (Science KS3); DFE, 2013 (Geography KS3); DFE, 2014 (Science K4))

Stage	Science	Geography
Key Stage 1 (5-7 years old)	identify and name a variety of everyday materials, including wood, plastic, glass, metal, water, and rock describe the simple physical properties of a variety of everyday materials compare and group together a variety of everyday materials on the basis of their simple physical properties identify and compare the suitability of a variety of everyday materials, including wood, metal, plastic, glass, brick, rock, paper and cardboard for particular uses	use basic geographical vocabulary to refer to: key physical features, including: beach, cliff, coast, forest, hill, mountain, sea, ocean, river, soil, valley, vegetation, season and weather

Key stage 2 (7-11 years old)	compare and group together different kinds of rocks on the basis of their appearance and simple physical properties describe in simple terms how fossils are formed when things that have lived are trapped within rock recognise that soils are made from rocks and organic matter identify the part played by evaporation and condensation in the water cycle and associate the rate of evaporation with temperature. recognise that living things have changed over time and that fossils provide information about living things that inhabited the Earth millions of years ago	describe and understand key aspects of: physical geography, including: climate zones, biomes and vegetation belts, rivers, mountains, volcanoes and earthquakes, and the water cycle
Key Stage 3 (11-14 years old)	Earth and atmosphere the composition of the Earth the structure of the Earth the rock cycle and the formation of igneous, sedimentary and metamorphic rocks Earth as a source of limited resources and the efficacy of recycling the carbon cycle the composition of the atmosphere the production of carbon dioxide by human activity and the impact on climate.	understand, through the use of detailed place-based exemplars at a variety of scales, the key processes in: physical geography relating to: geological timescales and plate tectonics; rocks, weathering and soils; weather and climate, including the change in climate from the Ice Age to the present; and glaciation, hydrology and coasts
Key Stage 4 (14-16 years old)	Earth and atmospheric science evidence for composition and evolution of the Earth's atmosphere since its formation evidence, and uncertainties in evidence, for additional anthropogenic causes of climate change potential effects of, and mitigation of, increased levels of carbon dioxide and methane on the Earth's climate common atmospheric pollutants: sulphur dioxide, oxides of nitrogen, particulates and their sources the Earth's water resources and obtaining potable water.	None – KS4 Geography is not statutory – it is an optional General Certificate of Secondary Education (GCSE) subject.

Optional geography GCSE courses were taught in England from 1986, whilst A Level geography courses were available for much longer. Nearly half the 16 year olds in the country take GCSE Geography as one of their eight to ten GCSE subjects, whilst a lower but still significant number take A Level geography as one of their three to four A Level subjects. The Earth science content of these courses is shown in Table 7.3.

Tab. 7.3 Earth science content of optional Key Stage 4 (GCSE) and optional post-16 (A Level) Geography courses [headings only]. Many students in England take these courses. (DFE, 2014 (GCSE Geography); DFE, 2014 (A Level Geography)).

Stage	Geography
Key Stage 4 (14-16 years old) Assessed by GCSE exam	[Headings only provided] Physical geography: processes and change Geomorphic processes and landscape Changing weather and climate
Post-16 (16-18 or 19 years old) Assessed by A Level exam	[Headings only provided] Water and carbon cycles Landscape systems

As with geography, optional geology GCSE courses were offered from 1986, whilst A Level geology courses, which are typically taught by trained geology teachers, were available prior. Both GCSE and A Level geology are minority subjects, with only a small percentage of students across the country taking them each year. Although the numbers of A Level entries fell over the years until 2005, they have mostly risen since (Figure 1). The enrolments consistently remain around one third female to two thirds male. GCSE geology entry also decreased then rose again recently and is now consistent at about 1000 entries per year. The content of these courses is shown in Table 4.

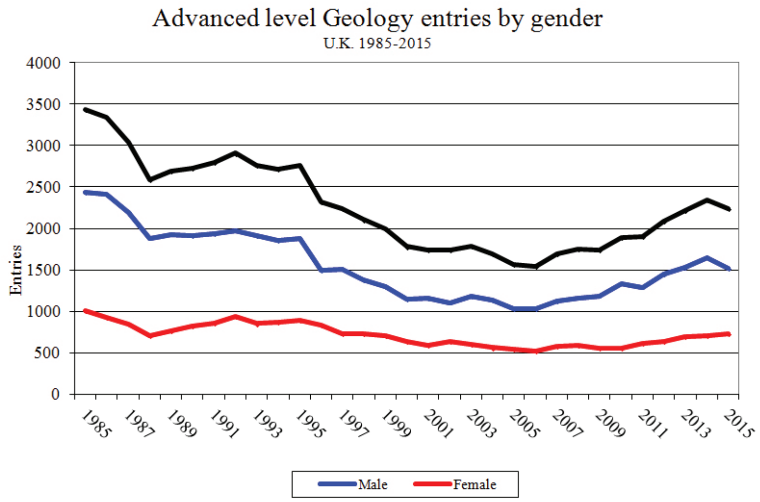

Fig. 7.1 A Level geology entries 1985-2015.

Tab. 7.4 Earth science content of optional Key Stage 4 (GCSE) and optional post-16 (A Level) Geology courses [headings only]. Few students in England take these courses. (DFE, 2015 (GCSE Geology); DFE, 2015 (A Level Geology))

Stage	Geology	
Key Stage 4 (14-16 years old) Assessed by GCSE exam	[Headings only provided]	
	Minerals Igneous rocks Sedimentary rocks and their fossil content Metamorphic rocks Structures Planetary geology Geochronological principles and stratigraphy Rock cycle	Plate tectonics Past global temperatures and sea level changes The origin and development of life Earth hazards and their mitigation Earth resources and engineering
Post-16 (16-18 or 19 years old) Assessed by A Level exam	[Headings only provided] - Core content	
	Elements, minerals and rocks Earth structure Global tectonics Surface processes: sedimentary environments and sedimentary rocks	Internal processes: igneous and metamorphic rocks Evolution of the Earth Earth materials and resources
	[Headings only provided] – Non-core content (two of the following seven areas must be included)	
	Planetary geology The lithosphere The stratigraphy of the British Isles	Quaternary geology Critical resources Geohazards Basin analysis

Data published by the UK Universities and Colleges Admissions Service (UCAS) shows that more than 40 percent of the applicants for undergraduate geology courses (2010 – 44%; 2012 - 43%) took A Level geology. A 2015 survey by the Earth Science Teachers' Association showed that 44 percent of those who passed A Level geology went on to study geology at university.

To summarize, in 2016 in England:

- the compulsory primary and lower secondary curriculum contained some Earth science as part of both science and geography;
- optional GCSE and A Level Geography courses carried some Earth science within physical geography;
- a few candidates took optional GCSE and A Level geology courses, usually taught by geology teachers.

7.5 Professional Development Available to Science and Geography Educators Teaching Earth Science

Research conducted in the 1990s (King, 2001) showed that most science educators teaching the Earth science component of the new National Curriculum for Science received little or no Earth science education themselves. To help with their Earth science teaching they usually used science textbooks written for their pupils together with assistance from their science colleagues (many of whom had also received a poor Earth science education). They usually did not use Earth science-specific teaching materials and rarely attended professional development courses on Earth science. Although they reported that their background, confidence and enjoyment in teaching Earth science and the interest and achievement of their pupils were all 'moderate', they did very little practical work and no fieldwork at all. This suggested that, whilst they thought their overall teaching of Earth science was 'moderate', it was more likely to be 'poor'. This view was reinforced when a review of the Earth science content of science textbooks used across England showed that more than half the National Science Curriculum Earth science statements were inadequately covered or not covered at all, and they were highly inaccurate, averaging one error/misconception per Earth science page (King et al, 2005; King, 2010).

This research was used as the basis for a bid to the oil industry (the oil industry trade association, *Oil and Gas UK*, formerly UKOOA) for funding to provide professional development to secondary (high school) science teachers in their own institutions, free-of-charge. The bid was successful, allowing the Earth Science Education Unit (ESEU) to form in 1999 and roll out this strategy across the UK. The oil industry funding was maintained for 16 years, and the remit was expanded to encompass primary and geography teachers, providing ESEU workshops to 11,979 teachers and 25,512 trainees (pre-service teachers), a total of 37,491 individuals by December 2015. Throughout this time, feedback remained excellent with 'effectiveness', 'interest', 'relevance' and 'value' on a 1 (high) to 5 (low) Likert Scale ranging from 1.57 at best to a low of 1.96. This was accompanied by many positive comments: *'I won't think rocks are so boring in future'*, *'I was made to feel enthusiastic about Earth sciences, which I never thought would happen'*, and '*The best INSET day I have ever had'*.

ESEU research conducted in 2003/4 and 2007/8 for all secondary school science departments visited in those years (31% return) showed that nearly all the schools changed their teaching Schemes of Work in response to the professional development (King & Thomas, 2012; Lydon & King, 2009). This positive impact was supported by anecdotal evidence, such as a comment from Newman University, *'PGCE tutors at Newman University, Birmingham had observed a noticeable improvement in Earth science teaching over the last few years when visiting schools and that was down to ESEU.'* By 2015 ESEU was visiting more than half the university secondary science training institutions in the country, showing that return visits were welcomed by the university tutors concerned.

These indicators suggest that Earth science education across England improved as a result of ESEU efforts.

7.6 Training Geology Teachers

At one stage in the distant past, there were six institutions training geology teachers across the UK. That number dwindled until the penultimate institution, Bath University, closed in 2011 and the final institution, Keele University, closed in 2013. Fortunately this decline was monitored by the Earth Science Education Unit, realizing that if geology graduates were no longer trained as teachers, the eventual effect would be the decline of geology teaching across the country. So industrial support was sought to run an intensive summer school to train practicing and newly trained science or geography teachers, with geology degrees, to teach A Level geology. Running these summer schools effectively for the past two years (Figure 2) has reversed the decline in the number of geology teachers trained in the UK.

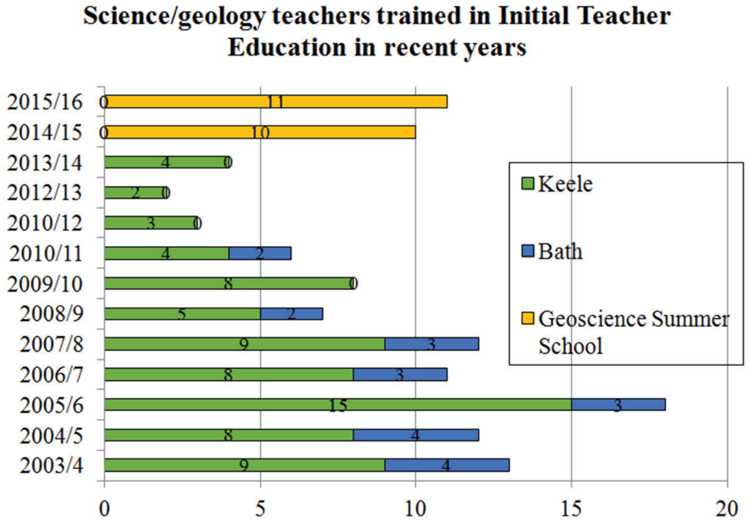

Fig. 7.2. The number of geology teachers trained in the UK since 2004.

7.7 Support for Earth Science and Geology Teachers

Support for those teaching geology and Earth science is provided by the voluntary Earth Science Teachers' Association (ESTA, formerly Association of Teachers of Geology, ATG) since 1966. In more recent years, support for Earth science education is also provided by the Scottish Earth Science Forum (SESEF), the Earth Science Education Forum (England and Wales) (ESEF), Earth Science Ireland, and the Education Committee of the Geological Society (Figs. 7.3 – 7.8).

7.8 The UK and the International Earth Science Olympiad (IESO)

In the UK, national science Olympiads are run by the Learned Institutions, the Society of Biology, the Royal Society of Chemistry and the Institute of Physics. When the Learned Institution for geology in the UK, the Geological Society, was invited to consider involvement in the Olympiad movement, they sent an observer and two students to the third IESO in Taiwan. However, on the return of the observer, the decision was made to take the matter no further at that stage. Nevertheless, this issue remains under discussion by the Geological Society.

7.9 Conclusion

Since the implementation of the National Curriculum, all students from the age of 5-16 study a small amount of Earth science as part of the science curriculum. This Earth science is mostly taught by science teachers who are specialists in biology, chemistry or physics. When research showed that their teaching of Earth science might be poor, the Earth Science Education Unit (ESEU) was instituted to offer them professional development in Earth science teaching. The ESEU work over 16 years shows a demonstrably positive impact on Earth science teaching in schools.

Throughout this time, Earth science also formed a small part of the geography curriculum, compulsory for 5-14 year olds and optional for 14-18 year olds; many students take the geography option, which is usually taught by teachers trained in geography teaching.

Also over this time, geology was offered as an optional examination subject to a small number of 14-16 and 16-18 year olds. Geology is usually taught by teachers trained in geology teaching and, although the government training of geology teachers has reduced in the past few years, the numbers have increased recently through an ESEU initiative.

This fairly positive picture might not have been possible without the dedicated hard work of a number of key individuals over the years. The importance of their work and of the institutions that have supported them cannot be overstated.

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Fig. 7.3 Presenting Earthlearningideas, 2013 (*Elizabeth Devon*)

Fig. 7.4 Testing Earthlearningideas (*Peter Kennett*)

Fig. 7.5 Training teachers, Keele, 2014 (*Pete Loader*)

Fig. 7.6 An Earth Science Education Unit workshop high school activity (*Elizabeth Devon*)

Fig. 7.7 An Earth Science Education Unit elementary workshop activity (*Denise Balmer*)

Fig. 7.8 Training teachers, Keele 2014 (*Steve Kilner*)

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Chapter 8

Teaching Geosciences in France: Linking Science and Education

Gérard Bonhoure and Mathieu Rajchenbach

Abstract

Earth science is taught to all pupils 13 to 15 years old, and mainly to those specializing in science between ages 16 and 18 in high schools. The content has been carefully chosen to allow them to build basic knowledge in geosciences and provide time for an active pedagogy. Memorization is limited, and understanding the mechanisms is essential. In class, the students are encouraged to follow scientific methods, ask questions, investigate problems, conduct experiments, and argue about their results. Teaching geoscience aims to build a systems representation of Earth, although the roles of the atmosphere and hydrosphere are limited. Astronomy, hydrology, oceanography, and meteorology do not appear in the syllabus.

A strong educational impact is sought. Understanding scientific methods and the relationship between science and human issues is fundamental. The link between teaching geosciences and education for sustainable development is included in the syllabus. It is a highly ambitious curriculum for the limited allotted hours.

This highlights the difficulty in preparing and selecting students for the IESOs. A specific online training (provided by "Sciences à l'école") can be used by the candidates with help from their teachers; the subjects are those of the IESO syllabus which do not appear in official French programs, especially in the fields of meteorology, hydrogeology, astronomy, and also geology. The selection is based on the results of the National Geology Olympiads, wherein students demonstrate their understanding of geological processes, and on a specific test based on the online training.

Keywords: Earth science education, Education for Sustainable Development, investigation

8.1 Introduction

In France, studying geology begins in middle school (5th level in the French system for 12 year old students) up to the end of high school (18 year old students, 2 level, 1st level, and "terminale" which is final level.[1]). Middle school is compulsory for all children in France, and all have the same program. In high school, geosciences are taught only at "general high schools" representing about 65% of the students, mainly to those who choose a scientific course of study (40%). Teaching geology and biology are taught as "Sciences de la vie et de la Terre" (Life science and Earth science). We begin with a condensed survey of the syllabus at different levels. Next, we consider how the geosciences pedagogy in the French system aims to build different competences, with two main purposes:

- Allowing every student to be more familiar with science and scientific methods, if they do not plan to become a career scientist.
- Allowing every student to become a knowledgeable citizen and to understand their responsibilities.

8.2 A continuous curriculum from middle to high school

8.2.1 Middle School: Geology is Considered as a Pillar of the Scientific Culture

In the national program, teaching sciences is meant to develop a scientific culture, shared by all citizens, to allow them to understand the world in which they live and have a better analysis of the issues for mankind. This is written in the introduction for both the biology-geology and physics-chemistry programs. The unity relies on the status of "experimental sciences" which constructs world representations through methods based on measurement, experiments, and all actions meant to check hypotheses ("*how we think it works")* versus reality.

In the 5th level, the subject title is "Geology: Landscape Evolution". It is meant to provide the first brush with geological processes starting with something very practical. The landscape is part of everyday life, it can be

1. *In the French system, levels decrease from 6 to 1, followed by "terminale" ! For example, 5th level comes BEFORE 4th level, etc.*

observed easily, some basic mechanisms can be tested with simple experiments, and it can be easily related the historical dimension of geology. The program insists that the landscape must first be studied locally to allow for practical work, and should include some fieldwork. It can also be related to questions of human development, which are also studied in geography. The following year (4th level) is organized around initial insights into internal Earth dynamics. About 18 hours are devoted to those subjects each year.

In the final year of middle school (3rd level), less time (10 hours) is devoted to the subject: "Evolution of Life and Earth History". The logic is that in biology one of the subjects is "unity and diversity of human beings". Both of these subjects contribute to understanding the foundation of evolution and biodiversity at different scales (from human genetics to organisms or ecosystems of the past, tens or hundreds of years for human generations to billions of years for life history).

At all levels, geology always relates to "Earth systems" and the goal is not to memorize as much as possible, but rather to understand the mechanisms and main processes. Some interdisciplinary experiences are also developed with other sciences or geography.

8.2.2 High school: from bases to more specialized approaches of geosciences

High school programs for "Science de la vie et de la Terre" were given a new structure in 2010. Instead of writing two syllabi, one for biology and one for geology, it is organized around three themes:

1. Earth in the universe, life, and evolution of life: the purpose is to understand that scientific methods are based on observation, argumentation, and experimentation leading to a coherent explanation of "how it works" (mechanisms) and "how it evolved" (history); in addition to building a scientifically literate culture, this is meant to help students become more familiar with professions related to fundamental sciences such as research and teaching;
2. Current "issues for planet Earth": is designed to show how thorough scientific knowledge is necessary for every individual, to make rational decisions and act as a responsible citizens. This perspective is cast on all professions, and especially toward all those involved in public decision making, sustainable development, agronomy, architecture, etc.;
3. Human body and health: the third theme relates only to biology.

In the 2nd form, all students follow the same curriculum in the high school and there is no specialization.

In theme one, the first question is: "Are the conditions necessary for life specific to planet Earth?" It leads to some comparisons between planets (3 hours, which is very short). In the second theme, two subjects relate to geosciences:

- "Sun: a fundamental supply of energy": after studying photosynthesis, the subject leads to understanding the origin of fossil organic sources of energy, such as oil and coal, the limits of those resources, the consequences on the atmosphere (carbon cycle), and of course "renewable energies" (solar energy, wind, etc.).
- "Soil: a sustainable resource?": the subject does not require students to build an exhaustive knowledge about soil but only to understand the issues about soil protection and the link with human activities, including agriculture.

In the 1st form, students have a choice between different curricula. Those who will follow a scientific pathway study these subjects:

- Theme 1: Plate tectonics, the history of the model. It is an important contribution to scientific culture, as it is a perfect example to show how science progresses, changes its representations and hypotheses with time and new investigation technologies.
- Theme 2: "Plate tectonics and applied geology": a good theory supports good predictions as to where resources (oil, minerals, etc.) are, with economical and geopolitical consequences!

In the last form, finishing with "baccalaureat" *(the final exam),* for scientific students the subjects are:

- Theme 1: "evolution of man", which at this level allows students to weave very strong links between biology and geology around the concept and the mechanisms of evolution.
- Theme 2: "dynamics of the continents": At this intermediate scale between the landscape and the planet Earth, fundamental knowledge about mountain forming processes, metamorphism, magmatism, and erosion are included in a cursory fashion in a very limited time (20 hours approximately).
- Theme 3: "geothermal energy" is related to the preceding theme.

To conclude this part, it is necessary to underscore that the time devoted to geosciences is very limited. It requires making difficult choices about the course content. The emphasis is on "understanding the mechanisms", so the knowledge required is carefully selected so as to allow the most rigorous, thorough argumentation, for a given level. The result is that French students do not have a wide knowledge about rocks, minerals, fossils; they are not asked to memorize lots of names and details. That will be for those who choose to delve further in university. They are asked to understand how things work so that, even if they do not become specialists, they can build connections between information they receive in the news and some fundamental knowledge. For example, relating an earthquake or volcanic eruption with plate tectonics; linking a geopolitical issue to the possible presence of oil; understanding the necessity of keeping some vegetation in relation to erosion and the history of a landscape.

8.3 Teaching Geosciences: Some Issues in Didactics and Pedagogy

8.3.1 Teaching a Scientific Subject

One of the important decisions made in writing the syllabus for geosciences in France is that "teaching the results of science is NOT teaching science". Science is a method for constructing a representation of the world. It is based on facts, questions, and argumentation. On the other hand, "ideologies" are not to be questioned; they are a "truth" and do not change with time; those who accept them "believe". In science, every model, every representation is meant to be questioned, and the "scientific truth" is essentially temporary. There are no "mistakes", but new revelations can demonstrate that the preceding theory no longer holds. There should be no "belief" in science. If a scientist doubts a colleague's results, he or she has the tools to test them, can make the same measurements, and try the same experiments. Scientific methods aim to be "universal", as its vocation is to be shared by all people. In France, it is considered important this be understood by every citizen. There is no conflict between science and religion; many scientists are also "believers" and belong to different religions. Yet when everyone discusses science, the rules are the same for all: the disagreements or differences, which can occur between scientists, are not "conflicts of opinions" (or should not be). Rather, it is a way of continually improving theories by trying to find better explanations, based on facts, on which all agree… temporarily at least.

To achieve (or try to achieve) this, the teaching methods may be more important than the content itself.

Of course, choosing the subject is one thing. The history of plate tectonics is a very good example to show how models change with the evolution of technology. Without understanding the asthenosphere's rheological properties, Wegener's theory seemed "unbelievable", because the relevant facts were unknown. With new knowledge, a new theory leads to new opportunities for finding new resources.

Selecting the teaching method is fundamental. In class, pupils are set in situations where they are allowed:

> - to ask questions, criticize an idea found in a document, text, or photograph showing a difference to what they have learned;
> - to discuss, and argue organized into small groups (2 or 3), working on different objects or documents showing different things. Then take conclusions from the small groups to exchange ideas with the whole class. Thus students learn progressively to listen to each other and look for the best argument in order to progress the discussion.

To help pupils learn what science is, they are given the idea that they should "act as scientists", with modesty of course. One of the methods used in France is the "inquiry method". The teacher prepares a situation, by going to an outcrop if possible, looking at a landscape, or preparing a set of objects and documents. From this starting point, students identify questions and then look for explanations. Sometimes they are given a set of facts (objects/documents) that will lead them directly to an answer. Other times, they are set free to choose their means, either using the Internet or designing an experiment. For example, looking for an explanation for ocean streams, students are frequently given test tubes, pipes, colored water, salt, heating devices, ice, etc. and asked to build a model that explains why water moves due to density differences. They work in teams of 2-4 then compare their models and results. Special classrooms are used for scientific teaching involving practical work.

The program itself is written in two columns: one for expected learning outcomes, the other the skills which must be developed. In this way, teachers have a very precise guide as to what they can prepare and what actions to expect from their pupils.

This approach takes time, hence why choices were made not to teach a lot of topics and to limit the scope of the syllabus. Allowing pupils sufficient time to act was considered a necessity, not just for those wanting to work as scientists, but for *all* citizens. Education follows the scientific formation. Every citizen should know how wrong it is to state that, "the scientific experts are not totally sure of this explanation… so there is no reason to take any action!"; no scientist, in theory, can be 100 percent sure! That's science. But the fact that an explanation is the most reasonable and the most widely accepted is a good reason to take it into account while making decisions.

Geosciences are unique as a subject to teach science, as they follow two different patterns of scientific methods:

- experimental methods: *e.g.* mineralogy and petrology, where it is possible to control conditions (pressure, temperature, etc.) to simulate different environments;
- historical methods: tectonics, mountain formation, and evolution, which cannot be examined through experimentation on the same time scale (except with computer simulations).

Therefore, geosciences afford students a very rich insight into "doing science", which is an opportunity not to be missed.

8.3.2 Geosciences: A World of Complexity Requiring a Global Approach

In accordance with the complexity of all geological events, "systems analysis" is found throughout geoscience teaching, at age appropriate levels. For example, the first exposure to geology, trying to explain how the landscape is shaped, leads to searching for explanations in rock properties, the action of water, tectonic history, human actions, the climate, etc. Becoming conscious of the multiple interactions, the necessity of a systems approach, and the limits of prediction reliability, is a very rich entry into science and in the relationships between science and human endeavors. Studying a mountain's formation history, in the last level, also leads to complex analysis at a higher conceptual level.

The "Earth system approach" is also in the French syllabus: interactions between atmosphere-hydrosphere-geosphere with erosion, and interaction with the biosphere included in many subjects such as evolution, formation of oil and coal, and the carbon cycle. It leads to the contribution of geosciences to Education for Sustainable Development (ESD, in French: EDD – Education au Développement Durable).

But the content is often limited. Meteorology is not a significant subject, included mainly within the physics syllabus, or as extracurricular activities in "meteo clubs". The study of planets represents at most 1 or 2 hours in 7 years of the whole curriculum. This explains in part the characteristics of the French preparation and selection process for the IESOs!

8.3.3 Teaching Geology and ESD

The relationship with ESD is explicitly mentioned in the syllabus at all levels. The high school program (Theme 2) is meant to be taught so as to associate scientific content with educational goals.

This can be done with all subjects dealing with geological processes influenced by human activity, or with direct impacts on people, their life and/or their activity, or both. The main topics become:

- all questions about external geological processes involving atmosphere/ hydrosphere/ geosphere such as erosion, sedimentation, and soil formation, as man is subjected to those phenomena with positive or negative outcomes;
- geosphere/hydrosphere resources: minerals, fossil energy, water; their location, their limits;
- risk reduction at different scales, linked with natural phenomena such as volcanic eruptions, seismic activity, tsunami, or related to human activity like air or water pollution, climate change, etc.

In brief, the general idea in ESD in France is to raise students' consciousness of the complexity of the situations and of the possible human influences. Every citizen should know that indetermination goes with complexity, and nothing is precisely predictable. Therefore, choices should be made by carefully balancing different issues according to the classical "three pillars of sustainable development": economy, social equity, and environment. But once the choice is made, everyone is responsible for the consequences. Understanding moral and ethical values such as responsibility and solidarity is a fundamental educational goal.

On the pedagogical point of view, a central principle is: "Eduquer au choix et non pas enseigner des choix", that is "Educate to choose but do NOT teach choices". The teacher should not say: "This is the correct choice", because he or she would have made the choice, not the pupil.

There are many pedagogical or didactical solutions for this. One approach is to start with a case study, requiring asking questions related to human decisions, or a problem occurring in a particular place (*e.g.* human consequences from an earthquake). This requires one to understand the geological process, to know why it occurs where it does, and to understand the consequences for Earth systems (that is "pure geology", with content and scientific methods) and for man. Then follow with a debate about "what can we do now", preferably with teachers from other disciplines (such as geography or economics). In this debate, the professors never give their solutions or their opinions, they are facilitators who allow the pupils to listen to each other, argue, discuss, and finally make their own choices.

It is not particularly easy. It takes time. The geologist must find relevant situations, cooperate with other teachers, and very often organize the debate outside the ordinary school timetable. The educational goal is not reached immediately. This method can also be applied with other subjects: life in the school, health, etc., where the ethical values of responsibility and solidarity also have strong meaning. Ideally, this teaching method can, eventually, contribute to the development of better citizens.

8.4 Selecting the French Team for the IESO

"Science à l'école" (SAE = "Science at school") is the organization that supports the selection process for IESO. All students studying in 1st form can compete. There is one condition: one teacher is responsible to register his or her team on site and agrees to help prepare the candidates.

Once this is done, they can access the SAE site to find support, including information about the many subjects in the IESO syllabus that are not included in the official French programs. Partnership with "Meteo France", the astronomical observatory of Paris, and the Museum d'histoire naturelle de Paris (Natural history museum of Paris) allows the content to be very high quality. The students and teachers have their work cut out for them, as the quantity is quite huge. About 3000 students registered in 2015. In May, an IESO test facilitates ranking those students according to their knowledge of what is on the site.

Independently, the national olympiads of geology are organized. The best students in the competition are first ranked by "academy" (by region). Next, the 30 best students receive a national medal. From those, SAE chooses the 4 candidates who achieve the best result on the specific IESO test. They meet for a week at the end of August to receive their final training, including visits and fieldwork.

Teaching geology in France is a tradition. The time allotted is very short, so the content is limited. However, the contribution to scientific understanding and education is important. Earth sciences are a very propitious subject to associate these two school goals.

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After teaching geology and biology for about twenty years in "classes préparatoires" (university level), Gerard Bonhoure became Inspecteur Général de l'Education Nationale (General inspector). Among his different missions, which included participation in Earth science education supervision in France, he is in charge of organizing ESD (Education for Sustainable Development) in the Ministry of education. As such, he strongly pushed for integrating ESD in different subjects, especially in the geology and biology syllabi, at college and high school level.

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Chapter 9

Earth Science in German Schools

Dirk Felzmann and Sylke Hlawatsch

Abstract

To give an overview of Earth science contents taught at a particular grade in Germany is almost impossible. This is due to the high diversity of curricula, which resulted from German federalism and the early separation of students into different types of schools.

Earth science content is mostly taught within geography. Therefore the educational standards in geography, which act as a framework for making curriculum, are outlined. Some remarks about the actual situation and developments of the school subject geography are sketched. Some schools offer Earth sciences as electives or optional working groups, known in German as *Wahlpflichtkurse* and *Arbeitsgemeinschaften*.

Since 2012, Germany selects national teams for the International Earth Science Olympiad (IESO). The selection process is coordinated by a section of the German Geoscience Union, the *Fachsektion Geodidaktik und Öffentlichkeitsarbeit der Geounion (HGD/DGGV)*. Students from all over Germany and their teachers are invited and encouraged to participate.

Keywords: geography, Earth science, education, curriculum, IESO, geosciences, Earth Systems Education

9.1 Germany's education system

The main point for describing the German school system is the sovereignty of each federal state to determine its own school education system. This sovereignty includes the structure and content, plus how education is managed. However, there are a lot of commonalities between the 16 different federal states (Fig. 9.1). Primary education extends from grade 1 to grade 4 (within some federal states to grade 6). This type of school is called "Grundschule". After grade 4 there is a separation based on students' cognitive capabilities. Students with higher performance can attend "Gymnasium", which continues from grade 5 to grade 12 (in some federal states to grade 13) and enables the "Abitur". This final examination permits entrance into university. Around 30 percent of all students reach the Abitur, and other 14 percent sitting an examination that grants only access to universities of applied science. Students with medium performance can take a final examination, called "Mittlerer Schulabschluss", after grade 10; students with lower performance can take an examination, called Hauptschulabschluss, after grade 9. Secondary education is conducted by schools other than Gymnasium, which only offer "Mittlerer Schulabschluss" ("Realschule"), which only offer "Hauptschulabschluss" (Hauptschule), which offer Mittlerer Schulabschluss and Hauptschulabschluss and which offer Abitur, Mittlerer Schulabschluss and Hauptschulabschluss ("Gesamtschule"). After completing Mittlerer Schulabschluss or Hauptschulabschluss, students attend a vocational school, which provides specific job training. It is also possible to switch to Gymnasium to achieve Abitur, if a student performs well.

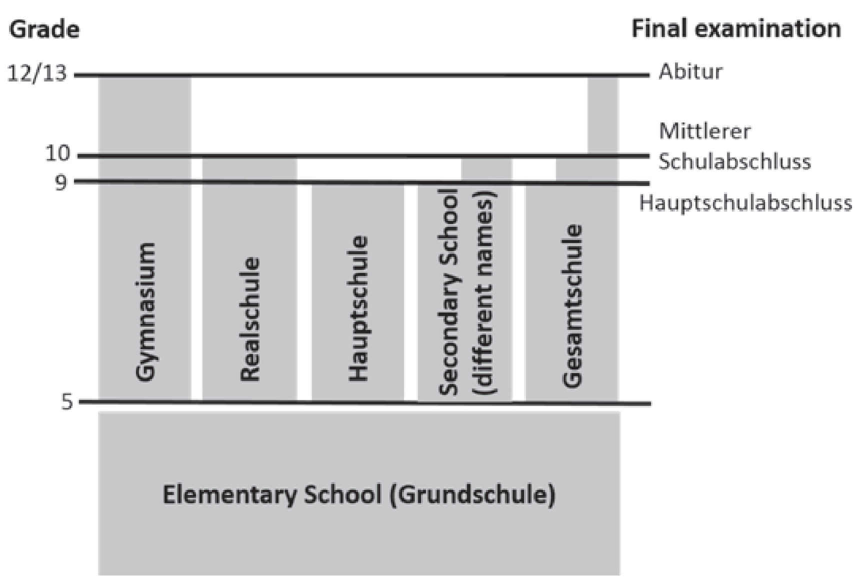

Fig. 9.1 The German school system structure for most of the 16 states. School for mentally handicapped children and vocational school are not displayed

9.2 Earth Science Content in the Natural Science and Geography Curricula

Within primary education there is a general science subject ("Sachunterricht"). This consists of social and natural sciences. After grade four there is a typically differentiation into six subjects: physics, chemistry, biology, geography, history, and politics. Sometimes, especially within the non-Gymnasium schools, these subjects are clustered to one subject for natural sciences and one for social sciences until grade ten. Within such clusters, geography is included in social science.

Each federal state defines its own curriculum for each subject at each type of school. Therefore, there is a huge variety of curricula for each subject across Germany, although standardization occurred over the last 15 years. The federal states developed together educational standards for "Mittlerer Schulabschluss" for biology, chemistry and physics. These standards represent a framework for the specific lower secondary education-curricula within the individual federal states. Because the federal states did not develop standards for geography, the German Geographical Society (DGFG) developed such standards (DGFG, 2012). These standards are not legally binding for the single federal states when they develop their geography curriculum. Much geography curricula introduced in recent years is, however, guided by these standards.

As outlined above, no subject like Earth science or geoscience exists in Germany. Very rarely the subject "geology" is offered in the two last years of gymnasium (grade 11/12) in some federal states. Within some states compulsory optional subjects with an emphasis on Earth science are offered to lower secondary classes ("Wahlpflichtkurse" or "Arbeitsgemeinschaften"). The question of whether such courses exist depends mainly on the initiative of individual teachers.

Earth science topics are mainly taught as geography. The educational standards in geography view geography as "a centralizing subject for all aspects of geosciences relevant to schools" (DGFG, 2012, p. 6). Therein it refers to the "Leipzig Declaration of the German Geographical Society and the Alfred-Wegener-Foundation" from 1996. Scientists from geography and geoscience define the main role of geography for teaching geoscientific content within this document.

Tab. 9.1 Subject-specific knowledge (K) in the Educational Standards in Geography relating to Earth Science topics (DGFG, 2012)

K1 Ability to describe the Earth as a planet Students can S11 describe the Earth's fundamental planetary characteristics (e. g., size, shape, structure, inclination of the Earth‘s axis, gravitational pull), S2 explain the position and movement of the Earth in the solar system and the consequences thereof (day and night, seasons). K2 Ability to comprehend different types and scales of spaces as physical geographical systems Students can S3 outline the natural spheres of the Earth system (e. g., atmosphere, pedosphere, lithosphere, biosphere, hydrosphere) and describe specific interactions, S4 describe and explain current spatial aspects of physical geographical phenomena and structures (e. g., volcanoes, earthquakes, drainage systems, karstic landforms), S5 illustrate past and projected physical geographical spatial structures (e. g., movement of geotectonic plates, glaciation), S6 describe and explain the functioning of spatial physical geographical factors (e. g., significance of climate for vegetation, of bedrock for soils), S7 outline the operation of spatial physical geographical processes (e. g., weathering, weather events, mountain formation), S8 outline the interaction of geographic factors and simple cycles (e. g., altitudinal zones of vegetation, ocean currents and climate, the ecosystem of tropical rainforests, the water cycle) as systems, S9 apply the knowledge acquired on the basis of examples to other spaces and places. K4 Ability to analyze human-environment relations in different types and sizes of spatial divisions Students can S17 describe and analyze the functional and systemic interactions among physical and anthropogenic factors in the use and shaping of spaces (e. g., choice of company location, agriculture, mining, energy production, tourism, transport networks, urban ecology), S18 illustrate the consequences of the use and shaping of spaces (e. g., forest clearance, water pollution, soil erosion, natural catastrophes, climatic change, water shortages, soil salinization), S19 explain and systematize the consequences of the use and shaping of spaces using selected examples (e. g., desertification, migration, resource conflicts, ocean pollution), S20 explain possible ecologically, socially and/or economically appropriate measures for the development and protection of spaces (e. g., development of tourism, reforestation, linking-up of biotopes, protection of geotopes), S21 transfer knowledge to other spaces at the same or different scale and outline similarities and differences (e. g., global environmental problems, regionalization, and globalization, capacity of the Earth and sustainable development). 1 The abbreviation "S" denotes the individual standards. In order not to break the flow when reading, the term "geographical" is used in the standards instead of the frequently used "geographical/geoscientific".

The educational standards in geography consist of the area of competence "subject-specific knowledge (K)" and of more process-oriented areas of competence: spatial orientation, gathering information/methods, communication, evaluation, and action. Within "gathering information/ methods", using maps and aerial photographs and other relevant sources is mentioned, as well as gathering information in the field (*e.g.*, observation, mapping, measuring, counting, taking samples).

By analyzing the subject-specific knowledge (Tab. 9.1) it is clear that the main topics of Earth science education are covered by these standards. However, more specific content such as volcanoes or the water cycle are only mentioned as examples. Biology's educational standards refer to the topics of evolution and ecology (KMK, 2005).

Because the curricula vary both within and between federal states and across the different types of schools, it is not possible to document specifically which topics are taught in German schools and at which grade. Tab. 9.2 highlights this diversity across the curricula for plate tectonics.

Table 9.2 The topic plate tectonics in the curricula of three different types of school from two different German federal states (ISB, 2009; NKM 2014a; NKM 2014b; NKM 2015)

	grade 5/6	grade 7/8	grade 10
Lower-Saxony			
- Gesamtschule	not mentioned in the curricula		
- Realschule		X	
- Gymnasium	X		
Bavaria			
- Gymnasium			X

9.3 General Issues Regarding Earth Science at School

- Within many federal states the amount of geography has diminished over the last decades.
- A predominance of human geography over physical geography in school curricula (ERNST, SALZMANN, 2004) and within the discipline of geography education (LETHMATE, 2013) is criticized.
- Many physical geographical topics in school deal with far distant places. It is recommended to teach more local topics to allow for more fieldwork (HARD, 1982; LETHMATE, 2011).
- In Germany a prospective teacher studies two subjects at university. Few teachers study geography and a natural science. From a geoscientific perspective it is criticized that many geography teachers lack fundamental knowledge of natural sciences (MARKL, 2002: MOSBRUGGER; OTTO, 2006).
- The creation of a social science cluster in many types of secondary-I-schools leads to an "isolation" of geoscientific topics within

a "sea of social science topics". These clusters are often taught by teachers who have a degree in politics or history rather than geography or any natural science.

- Conversely, an analysis of the German public revealed that the discipline geography is associated more with physical geographical topics than human geographical topics (GANS, HEMMER, 2015).
- Educational research revealed high student interest in the topic "planet Earth" (HEMMER, HEMMER, 2010).
- A broad interdisciplinary research group conducted the project "System Earth" to develop teaching material for upper secondary classes and for elementary school (HLAWATSCH, ET AL., 2003).

9.4 Bringing students to IESO

German national teams participated in IESO since 2012. Students and teachers do not feel comfortable joining the selection process, however, mainly due to absence of a school subject such as "Earth sciences". The schools that participated established optional courses for interested students. A homepage informs those interested about the German selection process, via the German Earth Science Olympiad (www.die-deutsche-olympiade-der-geowissenschaften.de). There, teacher and students find qualifying examinations and a contact address where they can register for selection by December, 20th each year. The Olympiad is supported by the German Geological Association (DGGV) and private sponsors.

9.5 Conclusion

The teaching of Earth Science topics in German Schools is characterized by the lack of a dedicated school subject and by a hugely diverse curricula resulting from different types of schools and different state regulations. The school subject geography sees itself as the main subject for teaching Earth Science topics. The Educational Standards in Geography indicate the high relevance of these topics and may be a starting point to develop a more coherent and binding framework, select which Earth Science topics should be taught and at which stage. More comprehensive Earth Science education within special courses at schools and student participation at the national and international Earth Science Olympiads is mainly the result of individual engaged teachers.

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Chapter 10

Earth Science Education and the National Earth Science Olympiad for Secondary School in Indonesia

Hendra Amijaya

Abstract

Indonesia is located in a complex geographical-geological setting. Considering that fact, Earth science should act as the backbone of teaching and learning natural sciences in the schools to understand the natural conditions of Indonesia. In secondary school, Earth science is included in geography, mixed with human and social geography. This means that Earth science education receives limited attention. Efforts to increase student competency in Earth sciences are needed.

One way to improve students' interest in natural sciences, Earth science in particular, is to invite them into a competition. Basic competencies in Earth science are expected to increase through this method. Since 2008, Earth science is included in the National Science Olympiad (NSO) scheme, which is conducted annually by the Ministry of Education and Culture as part of a government program. Selected high school students compete in the NSO after passing through local selection processes in their schools, regencies and provinces. The impact of the National Earth Science Olympiad is quite enormous. Students' willingness to study Earth science increases after introducing this program.

Keywords: Earth science, secondary school, student competency, National Science Olympiad, Indonesia

10.1 Introduction

Indonesia is a unique region in terms of its geographical-geological setting. Geologically, Indonesia is situated at the south-east edge of Eurasian plate where it meets other tectonic plates (Pacific, Indo-Australian and the small Philippine plate). The result is that Indonesia is located in a seismically active zone directly along the “Ring of Fire”. Indonesia also lies in a tropical area between two oceans (Pacific and Indian) and two continents (Asia and Australia), which yields a typical humid tropical climate year-round with high precipitation during the rainy season.

The Ministry of Education and Culture of The Republic of Indonesia (2013a) states that a student’s basic competency in secondary school should be fulfilled according to the 2013 curriculum: to understand, apply and explain factual, conceptual, procedural and metacognitive knowledge in science, technology, art and culture. This demand is quite high, requiring extra effort to actualize.

In terms of natural science education, Earth science should act as the backbone of teaching and learning to understand the natural conditions of Indonesia. In secondary school however, Earth science is included in geography, mixed with human and social geography. This means Earth science education receives limited attention. An effort to increase the student’s competency in Earth science is needed.

To entice students to learn more about Earth science and to improve the competency of Earth science education, a structured activity is needed. Therefore, since 2008, Earth science is included as one of the competition subjects in the National Science Olympiad (NSO) for high school students. This Olympiad is conducted annually by the Ministry of Education and Culture as part of a governmental program. Students from all provinces in Indonesia are selected. Selection is conducted at the local level in the schools, regencies and provinces before the national competition. This paper presents an overview of the Earth science teaching system and the science Olympiad program in Indonesia.

10.2 The Earth Science Teaching System in Indonesian Secondary Schools

In secondary education, Earth science is not taught as a special subject but included within geography. Basically, the subject is presented as a combination of physical geography (introduction to Earth and planetary science) and human/social geography. Due to this fusion, geography is thus included in the social science portion of the curriculum structure.

In the Junior High Schools (7th-9th grade), students are introduced to maps, the Earth's surface and interior, endogenous and exogenous processes, rocks and soil, and the atmosphere and hydrosphere. A small discussion about geo-resources and geo-hazards is also included. In the Senior High School level (10th-12th grade), students are expected to understand the dynamics of the lithosphere, atmosphere and hydrosphere, as well as the dynamics of solar system. Students also learn the effects of those dynamics on the availability of geo-resources and occurrences of geo-hazards.

As mentioned above, Earth science is included within geography, mixed with human and social geography. Therefore, Earth science is only considered in physical geography chapters, resulting in limited learning time, which means basic expected competencies sometimes can not be fully achieved. Moreover, Earth science education focuses only on spatial aspects and typically lacks discussion of the temporal-dynamical aspects of the Earth.

Teachers responsible for teaching this subject have mainly matriculated from geography programs, although some provinces in Indonesia even lack geography teachers, requiring these positions be filled by teachers from other natural science subjects such as biology or physics. Geography textbooks are available for each education level, but the challenge is that geography education is generally not accompanied by exercises or practical activities, which are critically important for learning Earth science.

Some deficiencies identified in teaching Earth science as "physical geography" are:

1. Some basic Earth science knowledge, such as rock or soil formation and classification, processes on Earth, plate tectonics, etc. is not correctly introduced to students. This is mostly because geography teachers have only limited understanding of Earth science. It also stems from the broad range of subjects, from physical to human and social geography, they are required to teach.
2. Each chapter of physical geography (and therefore Earth science) is discussed as a separate topic. It creates the impression that there is no relationship between each topic. Earth is discussed only as "a space", but not as "an evolving space". This results in a lack of understanding of the interrelationships between all processes on Earth and of the Earth as a dynamic system.

3. The lack of real and attractive examples, such as mineral/rock samples and field visits, creates the perception that this subject is uninteresting and rather difficult to understand.

10.3 Earth Science Education Competency Improvement in Indonesia

To provide a baseline standard of education, the government established a standard curriculum for all school levels. The curriculum was changed or modified several times, with the 2013 version the most currently applied model. According to Suyanto (2003), attention to improving teaching methods and student creativity seems to be overlooked in each of the past curriculum updates. Students act only as recipients of the teaching. The teachers present all materials without any student involvement in the learning processes. The implication of this (didactic) teaching system is that students know a lot of information with no understanding or connection to their daily life

According to the Ministry of Education and Culture, an indicator of high quality education is that which can deliver graduates who: (1) master the basic skills, (2) think rationally and independently, and (3) master general knowledge of various subjects (Dikdasmen, 2003). In accordance with that, the Ministry of Education and Culture released the CBC (Competency Based Curriculum) in 2004 to improve the quality of education in schools. The main idea of this curriculum is positioning students as the focus of the teaching and learning process. Teachers basically act as facilitators and motivators, while students are conditioned to take a more active role in their learning (known as a “student centered learning process”).

In the past, poor Earth science understanding resulted in a system that neglected the importance of science in daily life. For example, when geo-hazards such as landslides, floods, earthquakes, or volcanic eruptions occur, it is hard to warn and protect the public because they do not obey warnings due to their lack of understanding. The CBC is the practical solution proposed for implementation in Earth science education (Ministry of Education and Culture, 2013b). Therein, the concept of the Earth as a dynamic system is enriched. Students are motivated to learn not only in the classroom, but also in the field predominantly by observing and learning directly from their environment. However, the lack of teachers able to manage all subjects and educational funding, especially for laboratory equipment, continues to exacerbate the educational problems.

10.4 From the National Science Olympiad Towards the International Science Olympiad

Teachers and students need a structured activity to support the implementation of competency based curriculum and boost their interest in studying natural sciences, especially Earth science. One effective way is to offer a competition for students to showcase and be rewarded for their abilities.

The NSO is an annual science competition for students in Indonesia held by The Directorate General of Primary and Secondary Education of The Ministry of Education and Culture. The NSO for Primary and Secondary Schools commenced in 2000, with Earth science added for high schools in 2008, following on from participation in other subjects (physics, biology, mathematics, chemistry, informatics, astronomy and economics).

Student selection for the NSO starts at the school level in March each year. School representatives are then selected at the city/regency level, which is usually conducted in April. Winners of this selection round then progress on to the province level in June. Between 1500-1600 students from all of Indonesia participate in the National Earth Science Olympiad at this level every year.

The NSO usually occurs in August. About 90-100 students are invited to join the national selection process. Those students participate in a week-long program in which they sit written and practical tests in addition to extracurricular activities such as excursions and cultural visits (Fig. 10.1). The top 30 students are deemed winners to be trained and selected from as the four Indonesian delegates to the International Earth Science Olympiads (IESO) in the following year.

This activity definitely attracts students to learn more about Earth science. Additionally, it is an effective way to improve Earth science education competencies as teachers and students are encouraged to study well beyond the school curriculum.

10.5 Conclusions

Currently, Earth science education still receives limited attention at the secondary school level in Indonesia. Efforts to increase students' competency in Earth science is, however, needed. Inviting students into a competition can tempt students to learn more about Earth science and improve the overall capacity for Earth science education. Since 2008, Earth science is included into the National Science Olympiad scheme. Students follow a prescribed selection process, with winners trained and further selected to compete at the IESO the next year.

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Fig. 10.1 Students taking the written test (a) and practical test (b) during the National Earth Science Olympiad

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Chapter 11

Geoscience Education in Iran

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Abstract

Earth and space science is a significant part of the science curriculum in the Islamic Republic of Iran. In primary and middle school, Geoscience is included in the general science curriculum. But Earth and Space Science is an independent and separate subject in high school. Physical and historical geology, astronomy and applied geology are the main topics of interest in the mentioned curriculum. Inquiry-based learning is the main approach of Earth science instruction in Iran, but textbooks function as the main resources for teachers.

Key words: Earth and space science, progressive education, science curriculum, learning approaches, instructional method

11.1 Introduction

Formal education in the Islamic Republic of Iran includes both primary and secondary sections (Tab. 11.1). Elementary includes first and second rounds. There are also two rounds for secondary, the first is equivalent to middle school and the secondary or high school in other countries.

In the first and second periods of primary and middle school Earth and space science is part of the general science curriculum. Usually, it comprises about 15 to 25 percent of the content in science books. Typically, 2-3 of the 12-14 science learning units include geoscience and astronomy. The main topics of these units are: understanding and classification of our planet's materials, including air, water in its various forms, rocks, and soil.

These topics continue on in high school as progressive education. For example, in the first round of primary school, children get acquainted with descriptive classification of rocks based on their visible features, but progress in the second round on to classify rocks based on their genesis. Environmental issues such as air and water pollution also constitute part of the curriculum. The position and movements of the Earth and solar system are the primary space science topics. Endogenous and exogenous changes, a brief history of the Earth, the main surface features of the planet, and Earth's internal structure are important parts of the content of second round elementary section. Some issues related to the Earth sciences, such as geomorphology or orientation and maps are presented in Geography lessons

In the first period of high school (middle school), Earth science is still a part of the general science curriculum. At this learning stage, students continue the former topic progression, moving on to the economic importance of rocks and minerals, and conservation of natural and water resources. The theory of plate tectonics as the unifying paradigm for geosciences is introduced at this stage.

In the second section of high school, geology or Earth sciences is included within the natural sciences stream provided during the eleventh and twelfth years. In addition to promoting issues discussed in prior periods, the high school geology curriculum proposes teaching more detailed rock and mineral classification, using evidence to reconstruct Earth's history, becoming acquainted with geological maps and using them to obtain geological data and understand structural geology. A proposed new version of the secondary curriculum contains environmental science, however the content of this course is still uncertain.

Tab. 11.1 Educational system in I. R. Iran and earth science content in courses (curriculum and textbooks)

Stage	Round	Year	Earth and Space Science Courses		Main Topics
Elementary	one	1	4 units Integrated in science curriculum as separate sections		Air, water, rocks and soil observable properties
		2	3 units Integrated in science curriculum as separate sections		Earth rotation (day-night cycle), seasons, air and water pollution
		3	2 units Integrated in science curriculum as separate sections		Water cycle and resources
	two	4	2 units Integrated in science curriculum as separate sections		Genesis of three main kinds of rocks- planets, moon and stars
		5	2 units Integrated in science curriculum as separate sections		Formation and properties of soil- a short history of earth
		6	2 units Integrated in science curriculum as separate sections		Internal structure of earth- endogenic phenomena such as earthquakes and volcanoes
Middle-school 8 9		7	3 units Integrated in science curriculum as separate sections		Minerals and ores- water resources such as rivers and groundwater
		3 units Integrated in science curriculum as separate sections		Properties and uses of some minerals- simple classification of rocks- weathering-	
		3 units Integrated in science curriculum as separate sections		Fossils and earth history- simple astronomy- plate tectonics	
High-school 11 12		10	-		
		A Geology course for only math-physics and experimental sciences branches of academic stream.	3 units of environmental science course	Applied geology, specially geotechnics, medical geology, economic geology, geotourism and a simple geological history of Iran	
		-		-	

11.2 Learning Approach and Instructional Methods

A constructivist approach guides the main strategies proposed for teaching Earth and space sciences. This method begins by asking questions or presenting challenges. From this starting point, students participate in activities to test their ideas and finally form conclusions based on their evidence. This sets the stage for conceptualizing abstract or complex ideas. The complementary phase provides students an opportunity to elaborate with additional activities or assignments that allow them to consolidate and deepen their understanding of new concepts.

Many teachers try to teach geological concepts with hands-on experiences in natural environment. These hands-on activities create fertile ground for discovering patterns and relationships. Sometimes, in certain situations, teachers may use simulations and experiences in virtual environments. Various representations of scientific models, such as drawing, physical and virtual models and role play are used to explain patterns and relationships.

In first grade (primary section), about 25 percent of total book pages focus on Earth science. These topics are about Earth's materials including air, water, soil, and rocks. The rock unit teaches the use of variations in color, texture, shape, and heft to classify rocks, where they are found, and transportation in streams. The soil unit focuses on soil type variations, including color, touch, and main constituents therein, the main properties of soils (e.g. permeability), and the importance of soil for agriculture and providing food for humans. The water unit looks at the different forms of water in nature and their transformations. The air unit includes hands-on activities to experience air characteristics and the effects of air and wind on life and changes to other materials.

In second grade, three Earth and space science units comprise about 20 percent of the book pages. In the healthy air and water unit, students learn about the main sources of environmental pollution and methods to decrease it, such as recycling and improving traffic. Earth's rotation and its effects, such as the diurnal cycles, and its revolution around sun and seasonal cycles are additional topics in the second unit science book. Winds and their geological significance in arid areas are also among the core ideas in this grade.

Third grade contains two units of Earth science. In these chapters, students learn by hands-on and minds-on activities about water changes in nature. The main topic of these learning units is the water cycle, including the subtopics running water, ground water, water in seas and oceans, and the importance of water resources.

Earth and space topics in fourth grade are the main rock types and the solar system. In the rocks unit, students learn how to classify familiar rocks into igneous, sedimentary and metamorphic based on characteristics that provide clues to their genesis. In the night sky chapter, the solar system is the central topic, with the Sun, planets, Earth's moon and its phases as subtopics. Modeling is an essential teaching method in these lessons.

In fifth grade, Earth history and soil are main Earth science subjects. The Earth history chapter focuses on fossils and their application in reconstructing Earth's history, and relatively dating and interpreting environmental changes. The emphasis of the chapter on precious soil is soil formation and identifying its essential components, such as humus. Soil erosion and preventative methods are also included in this chapter.

Sixth grade geoscience is focused on the Earth's internal structure and evidence of the planet's restlessness. In one of these chapters, students learn about the physical and chemical properties of Earth's interior, especially those that effect seismic waves traveling through rocks. Students are presented with a classification scheme of Earth's internal layers, based on these changes in material properties. These layers include the crust, mantle and core (based on chemical properties), and lithosphere, asthenosphere in upper mantle, lower mantle and inner and outer core (based on physical properties). Earthquakes and volcanoes as clues to Earth's internal heat engine, is also presented in this grade.

11.3 Middle School (Juniors High) Earth and Space Science

Earth and space science is also one of fields in the middle school general science curriculum. In seventh grade, Earth science includes minerals and ores, water cycle components, and essentials of hydrogeology, progressing from the elementary curriculum.

Some of the important topics in this grade are: properties and economic applications of ores and industrial minerals, environmental issues in mining and industrial uses of natural resources, cloud formation and precipitation (including rain, snow and hail), watersheds and river basins, lakes, seas and seashores, movements of seawater, glaciers and their formation, groundwater and subsurface water distribution, porosity and permeability, aquifers (confined and open) and water table changes in aquifers, water quality and pollution.

In eighth grade, students are supposed to study three chapters about minerals, rocks and weathering. In the minerals unit, in addition to their applications and genesis, their environmental issues, such as asbestosis, are discussed. In the second Earth science topic of this grade, the main features of igneous, sedimentary and metamorphic rocks are presented with the rock cycle context. Gabbro, basalt, granite, rhyolite, diorite, and andesite are the main igneous rocks compared based on their mineralogical content and textures. The main sedimentary rocks in this grade are terrigenous, evaporates and biochemical. Chemical and mechanical weathering, along with some modes of erosion, constitute the final chapter.

Plate tectonics, historical geology and Earth in space are main parts of the ninth grade content. In plate tectonics, after a description of the evidence in its historical context, three boundary types are compared based on the phenomena that occur along each boundary and their mechanisms. The main topic of historical geology is fossils and their uses, specifically determining ages of rock layers and reconstructing environmental conditions when the rocks formed. The section on space includes the main topics: stars and constellations, navigation using them, galaxies and the Milky Way, our solar system including the Sun, planets, satellites, asteroids, and finally space journeys.

11.4 High School Earth and Space Sciences

In the second round of secondary section, Earth and space science is part of the 11th grade curriculum, but it is confined to the experimental science and math-physics branches. Some of the most important subjects in this textbook include chemical and physical properties of minerals and their classification, endogenous and exogenous phenomena that sculpt the Earth, structural geology, dating and historical geology, and stratigraphy. But a large part of the content of the textbook is devoted to applied geology. In this year's curriculum topics covered include geotechnics, hydrology and hydrogeology, mining and economic geology, medical geology, engineering geology, geology of fossil fuels, geo-tourism, and the geological aspects of natural hazards. Although some activities in the curriculum of this time exist, the prevailing approach is transitional and content-oriented. In addition of this course, another one titled Human and Environment (environmental science) consists of three chapters on soil, atmosphere and hydrosphere. In this textbook some geologic concepts integrated with some other scientific content are also presented.

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Chapter 12

Israeli Earth science education in schools

Nir Orion

Abstract

The Israeli Earth science curriculum is based on a holistic Earth systems approach. The main goal of this curriculum is to develop environmentally literate citizens. The curriculum materials emphasize the development of thinking skills such as scientific thinking, spatial and temporal thinking and systems thinking. Learning is inquiry based in variety of learning environments: laboratory, outdoor and computer.

Israeli Earth science education made meaningful progress over the last two decades, however its status in schools is still lower than the other sciences. The low status of Israeli Earth science education, as in many other countries, results from being trapped between the Devil and the deep blue sea: the conservative science education establishment, with its combination of ignorance and feelings of superiority preventing Earth sciences from taking an equal share in the school science curricula, and the geography education establishment, which refuses to free the Earth sciences and drowns it in social sciences lacking the knowledge to deal properly with this natural science field, from a combination of selfishness and feelings of inferiority. Only major involvement and vigorous action of leading Earth scientists among the top decision makers in the Ministry of Education might improve the status and profile of Earth science education in schools.

Key words: Earth science education, Earth systems education, inquiry based learning

12.1 Introduction

As other western countries, Israeli science education was influenced by waves of reforms, which moves like a pendulum between the constructivist paradigm and the essentialist conservative anti-educational paradigm. In the 90s, science education reform was due to the following three interrelated paradigms:

- The "Science for all" paradigm: wherein the main goal of science education is to educate our future citizens rather than preparing them to be future scientists.
- The constructivist paradigm: the educational model, which places the student at the center of the educational process.
- The "green" paradigm: the awareness of the environment in our daily lives. The "green" paradigm

This reform enabled Earth sciences education in Israel to move from being part of geography education to become an independent course of learning within the science curricula. The transition of Earth sciences from a neglected ancillary part of the geography curricula to an integral compulsory part of the science curricula was a long incremental process. As a result, a K-12 Earth science program was developed and implemented in the kindergarten, elementary and junior high school as part of the science curricula and as an independent scientific discipline in high school.

Each of the 40 K-12 learning units that were developed have the following characteristics:

1. Design based research.
2. Inquiry based learning.
3. Learning sequences gradually shift from the concrete to the abstract.
4. Context based learning (authentic and relevant context).
5. The outdoor learning environment is a central component.
6. Cover story.
7. Cross-curricular approach.
8. Adjusting the learning process for variant abilities learners.
9. Development of high order thinking skills.
10. Using the emotional aspect as a key for the cognitive aspect (Integration of the metacognitive aspect of learning).

These highly professional Earth systems inquiry-based learning units presented significant challenges for science teachers with no experience with such holistic teaching approaches, neither as teachers nor as learners. Therefore, implementing the Earth systems approach involved a massive in-service training program for elementary and junior high school teachers. However, for many teachers who had not previously experienced a learner-centered approach, such a change required a paradigm shift, which many of them resisted. Since the Earth systems pedagogical philosophy was (and still is) that quality is the essence of any educational process, implementing the Earth systems unit was offered to elementary and junior high school science teachers as privilege rather than an obligation. After a 5-year implementation program, hundreds of elementary and junior high school science teachers adopted the Earth systems based approach for teaching all aspects of the science curricula.

The enthusiasm of the students and their parents of the Earth systems science learning attracted more schools to join the program.

Unfortunately, in the early 2000s, the Israeli education system was washed over by the dark wave of standardized and over testing (national and international tests). As a result, teachers were forced to stop the inquiry based learning indoors and outdoors and were forced to prepare students for tests. This process has completely washed the Earth science program out of the junior high school science curricula over the past two decades. Fortunately, there are several schools that survived this destructive wave at the elementary level .

The shadow that the right-wing conservative government imposes over the Israeli educational system also has an adverse effect on the high school Earth science program. However, despite that murky wave, the determination of the Earth science program's leaders enables it to survive and to exist as an independent discipline in the Israeli high schools.

12.2 Goal and objectives of the Israeli Earth sciences curricula

The main educational goal of the Earth science curricula is the development of environmental insight. This can be achieved by internalizing the following principles:

- We live in a cycling world that is built upon a series of sub-systems (geosphere, hydrosphere, biosphere, and atmosphere) that interact through an exchange of energy and materials;

• Understanding that people are a part of nature, and thus must act in harmony with its “laws” of cycling.

This goal can be achieved through fulfilling the following objectives:

1. Acquiring basic scientific knowledge concerning the content and structure of the Earth's physical systems and the processes that occur within them.
2. Acknowledging and understanding the interrelationships among Earth’s systems that are based on transfer of matter and energy between and among them.
3. Understanding the human system among the other Earth systems.
4. Developing basic scientific skills of observation and the ability to distinguish between observations, conclusions and assumptions.
5. Developing thinking skills unique to Earth sciences: spatial and temporal (deep time) thinking.
6. Developing cyclic and systems thinking skills, which are needed for developing environmental insight.
7. Using the Earth sciences as a concrete and authentic platform for understanding abstract chemical and physical principles.
8. Developing appreciation for the beauty and uniqueness of our planet.

12.2.1 Fulfilling the objectives

Fulfilling the goals and objectives of Earth systems science required a holistic approach based on simultaneous efforts in all facets of the educational system.

• A holistic framework for Earth science curricula - Earth systems.
• A holistic learning environments approach: outdoors, lab, computer and classroom.
• The holistic Research-Development-Implementation spiral approach.

12.3 The Earth science high school program

The high school Earth science curriculum is an inquiry-based, learner-centered Earth systems program that integrates lab, outdoor, computer, and classroom learning environments. This program has three main components:

The introductory unit: This 270 learning hours unit involves acquaintance with Earth's systems and the interrelationships between and among them. It emphasizes the rock cycle and other biogeochemical cycles in the context of plate tectonics and Earth's structure. Another program emphasis is the role of society within Earth's systems. Most of the learning in this unit takes place in the lab and outdoor learning environments. An integral part of this unit is four one-day field trips and one two-day field trip. Each field trip includes 5-8 learning stops where students explore a few Earth system phenomena and identify the interrelations between the systems that are expressed by a concrete phenomenon. Following the field trip, students have to submit a report wherein they must engage their high order (cyclic, dynamic, etc.) thinking skills. Students identify cycles of matter and energy and interrelationships between the Earth systems that they were able to identify at the various field sites.

The Earth systems unit: This 90 learning hours unit was developed to strengthen the students' Earth systems knowledge and system thinking abilities initiated in the introductory unit. The unit starts with a two-day field camp to a small part of the Rift valley in northern Israel, which clearly expresses the natural Earth systems and the inter-relationships among them. The field camp also includes interactions with serious environmental problems, which were caused by non-sustainable development policies of the local inhabitants.

Following the introductory field camp, each student can choose to study one of the following Earth systems units:

(a) The carbon cycle and global warming (atmosphere and Earth systems);
(b) Oceanography (oceans and Earth systems);
(c) The Blue Planet (hydrosphere and Earth systems);
(d) Earthquakes in an environmental perspective (geosphere and Earth systems);
(e) From Dinosaurs to Darwin (biosphere and Earth systems).

Each of these five units is structured around inquiry-based learning and includes a final individual project. The students were instructed to include a systemic Earth systems analysis of the phenomenon they explored.

The Geotop unit: This unit is an investigative project that involves field and laboratory work. It engages scientific investigation processes by identifying research questions, making observations, collecting data, data analysis, and writing a scientific report.

12.4 The Earth Science Cross-Country class – an outreach program

The Earth Science Cross-Country (ESCC) class is a Web based program allowing high school students to major in Earth science. The reason for the development of this class is to bypass the Ministry of education's policy that places Earth sciences at a disadvantage relative to other sciences. This policy causes many high schools' principals to avoid offering their students the option to study Earth science. Thus, the ESCC allows us to pass over the principals' heads and reach interested students from schools all over the country directly.

The ESCC class program is identical to the regular Earth Science high school major curriculum. Thus, although it is mostly a distant learning class, the learning is still inquiry-based in various learning environments: class, lab, computer and field.

The two-year program is structured to provide students with basic scientific skills. <u>Year 1:</u> The focus is on rock, carbon and energy cycles in nature, as well as plate tectonics. Five field trips followed by field reports give the student a chance to practice and gain confidence in (1) makin observations and creating a new thesis; (2) analyzing feedbacks in complex systems; (3) self-managing time and resources in a scientific process.

By <u>Year 2</u> the students work in tight collaboration with academic researchers from Earth science departments from various universities. Students are paired with a research lab according to their interests to perform field and theoretical experiments such as: (1) Modeling future implications of climate change on the Mediterranean basin via paleoclimate analysis of a Foraminiferal collection; (2) Reconstructing the Geological history of the Red-Canyons region by mapping the crystalline bedrock.

Since its inception, the ESCC attracted learners from a vast range of locations, ages and scientific backgrounds. Facilitating this wide variety of learners along with the program's complex array of pedagogy is challenging, but very successful.

"One of the things I love the most about learning Earth science is how it all suddenly connects. I see how things, small things excite me and make me happy. Just recently, I said to myself: Wow! Maybe when I grow up I will be a Geologist, or maybe I'll be one of the people who teach this program." (A 12th grade student of ESCC).

12.5 Participation of Israeli Earth science students in the IESO

The decision for the Israel team to participate in the IESO came after much deliberation and lengthy discussions. This was controversial, since the connection between education and competition contradicts the educational perception of the Israeli program. The decision to participate was based on the following three reasons: (a) to provide students the opportunity to become acquainted with new places in the world and connect with new cultures; (b) to try to influence the educational perspective of the IESO; and (c) public relations through the Israeli media. It is important to note that since the Ministry of Education does not fund the delegation to the IESO, public relations focus only on increasing public awareness of Earth science within schools and not for the personal public relations of the Minister of Education.

IESO participants are selected only from high school students who study Earth science as a major discipline. The team selection process has three stages. The first (national) stage includes all Earth science students indicated by their teachers as as having high potential prospects. Students are evaluated in six categories: knowledge; ability to deal with several hours multiple choice written tests; oral presentation skills; English communication; social skills; and leadership skills.

The best eight students are invited to a two-day camp, which enables the mentors to get a better impression of the students' abilities. The camp also includes some subject learning that receives relatively less attention in the program. But on the whole, the students who participate in the ISEO arrive with the knowledge and skills that they acquired through the regular school program.

Following their participation in the Olympiad, the four members of the team share their experiences of the IESO in their schools and with students of others school and became ambassadors of the Earth science program. The follow-up activities include the Earth science teachers as well in a whole day meeting, where they review the different assignments of the ISEO and discuss what they can learn and adopt from that.

12.6 Summary

Israeli Earth science education made meaningful progress during the last two decades, however its status in schools is still lower than the other sciences. The main obstacle is the science education establishment that includes bureaucrats and scientist, who hold an old fashioned (17th Century) perception of the essence science and therefore do not understand the importance of this scientific field. The result is that Earth science education in Israel, as in many other countries worldwide, is trapped between a rock and a hard place. Only significant involvement and vigorous action from leading Earth scientists among the top decision makers in the Ministry of Education might improve the situation for Earth science education in schools.

Prof. Nir Orion

Prof. Nir Orion received his BSc from the Hebrew University of Jerusalem in geology and biology in 1980. He earned his MSc in 1984 and his PhD in 1990 from the Weizmann Institute's Department of Science Teaching. He established the Earth and Environmental Sciences education Group in 1996 and a Full Professor since 2013.
Prof. Orion is a pioneer in earth science education and his innovations range from the kindergarten to high school re- search projects. Altogether he and his team have developed about 40 sci- ence programs. He has helped elevate earth science education and the outdoors learning environment as an integral and legitimate part of the Israeli education system.

In 2004, UNESCO adopted Prof. Orion's *Blue Planet* curriculum for junior high school students, translating it into five languages and distributing it worldwide. *Blue Planet* like all his curriculum matrials promotes the development of environmental insight through understanding of the interrelationships of the earth systems including human. His materials and methods are spreading worldwide through workshops for teachers in many countries such as Argentina, Chile, Brazil, India, Peru, USA, Uruguay, Portugal, Spain, Germany.

Since 1998, Prof. Orion has been Coordinator of Earth Science Education for the Israeli Ministry of Education. In 2001 he was awarded the Israeli Geological Society Medal for his contribution to society through earth science education and in 2012 he recieved the prestigious IUGS Science Excellence Award on Geological Education.

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Chapter 13

The teaching-learning of earth science in Italy

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Abstract

The general opinion of schools and society regarding Earth sciences is biased towards natural catastrophes or simple collectibles, resulting in minimal attention in Italian educational systems. School teachers' background and in-service development often neglects this field of the scientific panorama, regardless of its calculated economical and social importance. Recent reforms of the Italian school systems attempt to direct interest towards geosciences, but the long-required turn towards a more investigative approach or problem-based learning, with adequate laboratory supports, still seems remote. Teachers' associations, such as the National Association of Natural Sciences Teachers (ANISN), and academic institutions, such as the University of Camerino, are trying to boost interest in schools and in the higher levels of the Italian educational system. Through organizing and supporting the Natural Sciences Olympiads that contain a full section on Earth Sciences, these associations help Italian students participate in the International Earth Science Olympiads programs. The need for an Earth science epistemology, the persistent lack thereof, and resultant consequences are also discussed.

Keywords: geosciences, school education system, student olympiads, epistemology

13.1 Introduction

In Italy, as in many other countries, the feeling of pupils, students, and even common people towards Earth sciences is strongly conditioned by the idea that Geology is only concerned with "stones and catastrophes". Earth sciences are badly perceived by the lay community because they only appear on the agenda when something dramatic occurs, such as natural disasters, earthquakes, floods, volcanic eruptions, tsunamis, or whatever events can attributed to "Earth's anger".

In effect, an investigation by the Italian National order of Geologists on the first 50 years of the Order of the Geologist, (http://www.geologiveneto.it/wp-content/uploads/MANIFESTO-GEOLOGI-ITALIANI1.pdf) clearly detected that geology only reaches the public eye when dramatic events occur. Even recent discoveries, such as plate tectonics in the late 70s, are not apparently well known by the general public or deemed important for citizens. The general basic ignorance of natural phenomena provokes widespread difficulty understanding the connected reasons for dramatic geological events and how to prevent or mitigate their effects with good public practices or civil protection. Moreover, geological subjects are too often attributed and delegated to professions other than geologists, and the role of the geologist is often confused and not well recognized.

This fact is harmful if we consider that the geosciences are "useful sciences" (Predonzan and Bellieni, 2002) in order to know and understand our planet and they can "help to create a planetary perspective" (Dal Re Carneiro, 2004). In 1992, a study published by the Italian Geological National Service (Catenacci, 1992) summarized the history of Italian environmental disasters starting from the end of the Second World War (1945) up to 1990. Their results showed that over this 45 year period one person died every two days due to an environmental disaster. Moreover, from 1990 to present, the situation has not improved, as shown by Valensise and Guidoni (2014) in their analysis of the impact of natural disasters in Italy from 1861 to 2013. Thus, we feel quite confident affirming that, at least in Italy, a more permeating culture of geological education in schools, and more broadly within the general public, could be as beneficial as biological or medical education, especially in terms of saving economic resources and human lives. Finally, particularly serious is the weak research on Earth science pedagogy and philosophy. We need a strong disciplinary epistemology because daily encounters with natural hazards and risks require local communities to be increasingly more aware of natural phenomena, whether beneficial or catastrophic, as they always make a direct impact on everyday life.

Moreover, the small number of Italian students enrolled in Geological Sciences degree programs clearly shows the unimportant role played by Earth sciences in Italian scholar education. During the 2012/'13 academic year, only 1540 out of 228,208 Italian freshmen students entered Geology programs; conversely, 5361 students enrolled in Medicine courses, almost four times the number of geology students (www.anagrafe.miur.it).

Educators, more so than others, need to master the content, be passionate about it, and be able to pass that passion on to their students, using interesting, interactive, motivating educational approaches. Doubtless, one of the reasons why this does not happen is that most teachers in secondary schools, colleges and high schools come from a background in Life Sciences (*e.g.* Biology) which is, at least not generally, a useful path to engender deep explanations of plate tectonics or natural risks and hazards.

13.2 The education system and the earth sciences

Natural Sciences education in Italian schools was born during the Gentile Reform in 1923 (R.D. 06/05/1923, n°1054) that aimed to foster a humanistic culture in the younger generations of the Italian bourgeoisie. Sciences, currently, are poorly taught, and often considered of secondary importance and not particularly effective in nurturing the skills required by the National Minister of Education for the European Skills Passport, and in the view of the Europe "Horizon2020" program. Among natural sciences, Earth sciences are often considered even less important – an unwanted step-child or "Cinderella" of the sciences – although the new secondary upper schools' curricula seem more considerate of this subject, which is developed (at least in the Lyceums) along the five-year school course.

In most Italian secondary schools, programs include a subject called Natural Science, comprised of Biology, Earth Sciences and sometimes Chemistry.

From previous studies (Costa and Zauli, 1982), we know that traditionally most Italian high school Natural Science teachers have a degree in Biology and just a small percentage have a degree in Natural Sciences or Geology. Therefore, most of the Italian Natural Science teachers have no geological background and are unconfident teaching Earth sciences. The main consequence to date is that Earth sciences receive less attention than Chemistry and Biology in Italian schools. Another study (Massa e Pedemonte, 1983) reported that 68 percent of teachers consider Biology the first most important subject, while only 15 percent ranked Earth sciences in the first position. Today, there is no updated data concerning Natural Science teachers' degrees, but the situation seems largely unchanged in the last 30 years.

As Earth Sciences learning is not a priority among the disciplinary choices of science teachers, the related teaching materials and instruments are often the last (and least used) on the school's "shopping list". This happens even if, as shown later, Earth sciences require instruments and tools that are often cheaper than, for example, chemistry or biotechnology ones. In Italian schools, the most common teaching approach is the transmissive lesson, whereby a teacher gives a speech in front of their pupils, who generally are required to take notes and report what the teacher said. Even though laboratories are explicitly required by the new national guidelines, and whose usefulness is confirmed in Earth sciences learning (Frodeman, 1995), are relatively rarely included in lessons (Berlinguer, 2008).

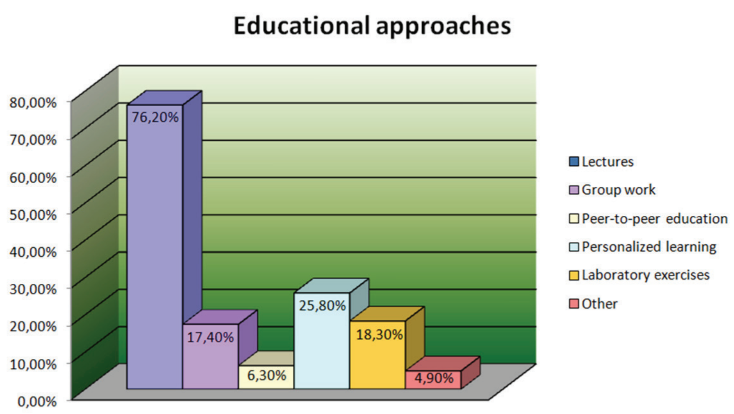

Fig. 13.1 Educational approaches used in the daily teaching sciences in secondary schools - Results of monitoring of the Indications (National curricula from Ministry of education) - (lectures 76.2%; group work 17.4%; peer-to-peer education 6,3%, personalized learning, 25.8%, laboratory exercises 18.3%, other 4.9%)

This traditional approach, suitably called "sage on the stage" in the English vernacular, represents a common teaching method in which one-directional teaching from the teacher to the student prevails (Figs. 13.1 and 13.2), is far from the Ministry of Education's demands and the needs of students for personalized and inclusive teaching. It is also far from an effective teaching-learning environment that, in the case of these disciplines, is especially reliant on active learning.

It is true, however, that in Italy the limited availability of educational tools, laboratories, high quality instrumentation, general equipment, or even rough materials, makes teachers' work particularly complex and discouraging.

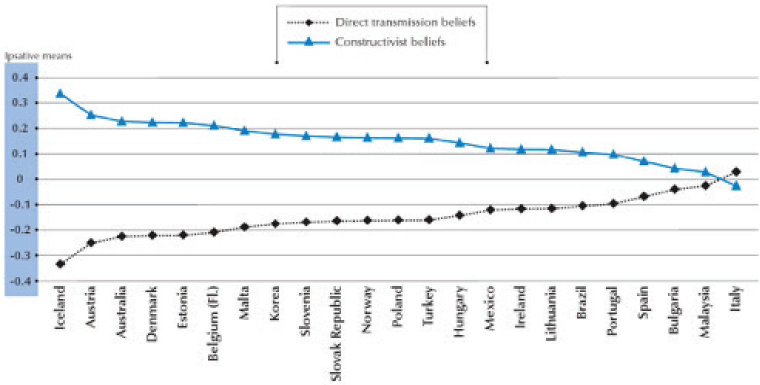

Fig. 13.2 Country profiles of beliefs about the nature of teaching and learning (from-OCSE 2008 TALIS- creating effective teaching and learning environments)

The practical-investigative approach or inquiry, problem-based learning, requires, "learning objects" to touch and manipulate in order to garner interest, involvement and scientific skills. Hands-on learning also engenders greater mental flexibility for both students and teachers.

Following the recent upper secondary school reform (2010) in almost every Italian Lyceum, there is a Natural Sciences curriculum (that includes Earth Sciences, Biology and Chemistry) distributed over a five-year course. Teaching methods are affected by the limited weekly teaching time, and practical activities such as laboratories and fieldwork rarely occur.

Since the Gentile Reform of 1923 and minor changes introduced in 1952 (D.M. 01/12/1952, n.34), the teaching organization of high schools in Italy has remained substantially unchanged until recently. In 2010, a more modern school reform (D.P.R. 15/03/2010 n. 89) partly modified the curricula. For Natural Sciences (including Earth Sciences, Biology and Chemistry) this new law now prescribes uninterrupted teaching in high schools (as stated previously, it is a five-year course in the Lyceums, but only a two-year course in most technical and professional high schools) and abolishes the timing boundaries between the different science subjects, providing general guidelines for the five years in which the course of Italian high school studies is developed: 1st biennium, 2nd biennium and 5th year. As of 2015, the new curricula reached the end of the first five-year cycle. It would be beneficial to know how this has actually been implemented for managing high school teaching in Italy into the future

The following secondary schools that include a 5-year Natural Sciences curriculum are available for Italian students from 14 to 19: the Scientific Lyceum, the Applied Sciences Lyceum, the Humanities Lyceum, the Language Lyceum, the Social Sciences Lyceum, and some high schools of the Arts. They present the following Science curriculum:

First biennium (1st and 2nd year): Planet Earth (Solar system and movements of the Earth); Geomorphologic study of Earth's surface; hydrosphere, atmosphere, geomorphological structures (rivers, lakes, glaciers, seas).

Second biennium (3rd and 4th year): Introduction to mineralogy and petrology (Minerals and Rocks); volcanism, seismicity and orogeny (Endogenous phenomena).

Fifth year: Meteorological phenomena; Global Plate tectonics; Relationships and interactions between systems (lithosphere, atmosphere, hydrosphere) and their phenomena; Earth as a complex system.

In the first biennium, that also concludes compulsory education in Italy, nearly all teachers base their school programs on what is expected in the National guidelines, while in the second biennium the compliance decreases, due to specific choices made by every individual school. In fact, each Italian school constructs its own "Plan of Training" (POF: Piano dell'Offerta Formativa) that offers certain freedoms of choice for teachers and schools.

Continuity through the different education levels are not evident, particularly when searching for fundamental themes and essential key issues; significant educational tools, to use and share, are not often proposed; methodological approaches, particularly useful when working with a constructivist and recursive approaches, as requested by the Ministry of Education, are not frequently suggested.

This survey suggests that, due to the lack of clear indications from the Ministry, the new curricula are implemented autonomously by teachers, substantially grounded in the old curricula. The heterogeneous choices for the final year could be affected by uncertainty about the first post-reform state exam.

On the other hand, data about the organization of teaching times are not surprising: the limited weekly time allowance makes teachers' strategies somewhat obligated and predictable.

The small number of science teachers with a degree in Earth sciences causes a partiality towards Life Sciences. A recent investigation among Earth sciences students and young geologists clearly shows that their ideas about their future job, or even their life dreams, are linked to climbing volcanoes, making discoveries in Antarctica, deep ocean immersions, possibly research and scientific awards; not exactly teaching at school, where we generally find many women and in much smaller numbers.

Conversely, teachers with a high degree of professionalism and a personal interest in Earth science, seem to be, not surprisingly, instrumental to improving teaching and learning. This happens especially with teachers involved in active teaching and learning approaches. More thorough support for teachers seems, therefore, to be the priority issue to obtain good short-term, and more durable results.

13.3 The Earth Sciences Olympiads and ANISN

One of the most effective tools to promote the study of Earth sciences is doubtless ANISN's (National Association of Natural sciences Teachers) sponsorship and organization of the Natural Sciences Olympiads and the subsequent participation in the IESO. More than 14,000 students in a thousand secondary level schools, mainly Lyceums, participated in the initial selection within their own school, and then at a regional level. The effort will hopefully involve more of the technical schools in the coming years. In the last three years, 80 to 100 high school students, half from the first biennium and half from the second biennium, participated in the national phase of the Italian Olympiads, which took place at Castellammare di Stabia, near Naples.

The initiative is sponsored by the Italian Ministry of Education, which recognizes the best students with a scholarship and inclusion in the National List of Excellences.

The trials of the Italian Earth Sciences Olympiads are comprehensive with theoretical questions, problem solving, and case studies. They also evaluate knowledge of basic facts, names and processes as a jumping off point for more extensive teaching in subjects concerning geology, astronomy, Earth history, hydrology and other Earth sciences. Questions and trials are organized by a national committee of teachers, researchers and former student winners from the previous editions.

The 10 best students out of the national competition are invited to a 7-day research-and-study stage at the University of Camerino, where they improve their competence with field-based research, Earth science lab investigations and further studies. During this stage, they are mentored by high school teachers and university researches and staff, but are mainly invited to work in a cooperative-learning, peer-review setting. This is the rationale for allowing 10 students to participate at this stage even though only 4 students compose the Italian IESO team, in order to have a wider discussion group and a more cooperative contest. The partnership with Camerino University has lasted five years, providing students with a Certificate of Competence and College credit in the Faculty of Earth Sciences. This stage is always a learning and cultural experience, but also a moment of socialization and personal growth for students and teachers.

13.4 Unicam, a network for Earth sciences

The main objective of these initiatives, with the numerous events organized by geological associations, such as Geoitalia, the Italian Geological Society, the Society of Mineralogy and Paleontology and many universities, with Camerino University as the lead, is to promote interest in Geosciences in the scientific community, the schools and in society as a whole.

The first step is creating a network organized by UNICAM through different events: July 2013 (Camerino Workshop), September 2013 (Geoitalia, Pisa), September 2014 (SGI e SIMP Congress, Milano). The network has the support of several scientific groups from universities, research agencies, schools, museums. This is a testament to the interest in this initiative and the need that many feel about the importance of more effective Earth sciences teaching and learning in Italy.

13.5 The need for an Earth science epistemology

Earth science is a complex discipline: the world complex should be clearly used in its real meaning, from the Latin *cum plicato*, bent together. It means a context rich in relationships, interacting in all their different components that, together, constitute a system. Complexity of a system, though, does not depend only upon unknown details of its structure and relationships between its parts, but is an intrinsic property, independent from detail knowledge, something that “does not disappear even when the functionality of the system can be completely rebuilt from its simple elements” (Cini, 1995).

A complex system is defined by “characteristics of self-reference and self-organization aimed at ensuring the stability of its structure and the reproduction of its components through the maintenance of the processes necessary for its survival” (Maturana and Varela, 1984). A complex system can not be static, nor linear, but is a combination of random processes and non-linear interactions: the result of an evolutionary process in which it is not possible even to recognize cause-effect relationships between components, because all are the result of their common history. Because of this complexity, it is difficult to recognize a formal unique structure of Earth sciences, which could allow the elaboration of a proper epistemology. Generally, every scientific discipline is based on its epistemology, which is necessary to deal with the fundamentals of the discipline itself, with the conditions that facilitate building scientific knowledge and, finally, with the methods to achieve this knowledge. In opposition to the philosophy that inspired the work of the founders of modern geology, from Steno to Lyell, between the eighteenth, nineteenth centuries and the first half of the twentieth century, Earth Science is now characterized by research from a large number of specialists, each mindful of its own highly specific field, and surely not interested in epistemological theories of the discipline. For this reason, geology is often thrown into the "mould of physics", regardless of the distinctions (Iannace, 2011). Geology also contains non-historical aspects that deal with organization and processes. A balanced understanding of our science requires considering all these facets. Even uniformitarianism, a fundamental principle of geology, remains fragile from the theoretical point of view, because of interruptions found in deep time data, or incompleteness of the stratigraphic and fossil records, which precludes direct observation (Frodeman, 1995). Earth sciences, by its nature, seems to be particularly interesting for the development of an epistemology of complexity, particularly within a non-linear framework, which is useful when linear models are too simple or inadequate. In a non-linear model, every component, every phenomenon, must be related to other systems, as in chaos theory, and it is not necessary, nor possible, to find a separate law for every fact.

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Chapter 14

Involving Japanese students into geoscience and growing up them to send IESO

Norihito Kawamura, Ken-ichiro Hisada, and Yutaka Takigami

Abstract

Earth Science Education is compulsory in elementary and lower secondary schools in Japan. In lower secondary school, natural science classes deal with quite basic geology, meteorology and astronomy following on from the basis of science class in primary school.

"Basic Earth Science" classes are primarily for general high school students. While junior high school science classes deal with regional phenomena, high school students build on this knowledge of plate tectonics, volcanism and seismic activity, Earth's evolution, global atmospheric circulation, and the origin of the universe, etc.

The Japanese national selection process for the IESO consists of three steps. First, the preliminary selection is held in various provinces. About 2000 students from almost all across Japan now participate in this written test. Approximately 60 students who win the preliminary contest sit a second test. Finally, 10 winners advance to the finals. The final test is in English, although the preliminary and second selections are conducted in Japanese. We select four delegates for the IESO through the final test.

The training program to prepare for the IESO extends from April and September until just before IESO. The JESO committee runs two delegate training camps with research organizations, such as museums and universities. The training camps are designed to improve the students' knowledge and Earth science abilities, while building mutual understanding among them.

Keywords: Course of Study, curriculum, school system, JESO, Japan

14.1 Introduction

The Japan Earth Science Olympiad Committee (JESOC) has run the Japan Earth Science Olympiad (JESO) for nine years, promoting Earth science among students and serving as motivation to study Earth science. This report shows how JESOC has conducted JESO. Firstly, educational systems in Japanese schools are described. Then, the authors introduce the JESO outline. Thirdly, the selection process and training programs for delegates of IESO admitted by JESOC are shown in sequential order. Finally, the authors provide a simple overview of JESOC's human and financial affairs.

14.2 Earth Science Education in the Japanese School System

14.2.1 Outline of Japanese school curriculum

The curriculum of elementary to upper secondary schools (high schools) in Japan is shown in "The Course of Study". The ministry of education administrated the curricula of all subjects since the start of the modern school system in Japan. Elementary and lower junior secondary (junior high school) education is compulsory. After graduating junior high school, almost all students enter high school to complete upper secondary education. Sixty percent of high school students apply to enter university or college for higher education.

The curricula are revised about every 10 years by the national educational division. The latest version was updated in 2008 by the Ministry of Education, Culture, Sports, Science and Technology (MEXT). These curricula show the study content in all subjects. Table 14.1 shows the Japanese science curriculum framework, Earth science in particular.

14.2.2 Earth science in "Science" for elementary school students

Under compulsory education, students must study the subject "Science", a general science or natural science course dealing with physics, chemistry, biology, Earth science and astronomy. Third to sixth grade students in elementary school study some Earth science topics around typical weather in Japan and motions of our Moon and Sun in the sky. Phenomena related to running water processes, strata formation, earthquakes and volcanoes are taught in upper elementary school grades.

Tab. 14.1 Earth science curriculum framework in Japanese school system

Gr.	**School**	**Subject**	**Fields of earth science and contents**		
			Solid-Earth science	Meteorology	Astronomy
1	Elementary school				
2	Elementary school				
3	Elementary school	Science		Ground temperature	Movement of sun
4	Elementary school	Science		Air temperature, Water vapor	Movement of sun and moon
5	Elementary school	Science	Running water processes	Change of weather	
6	Elementary school	Science	Volcano, Earthquake, Strata		Phase of moon
7	Junior high school	Science	Volcano, Earthquake, Rock, Strata, Fossil		
8	Junior high school	Science		Generating cloud process, Air mass, Weather in and around Japan	
9	Junior high school	Science			Physical properties of sun and moon, Movement of stars, Phase of Venus
10-12	High school	Basic Earth Science	Basic geology, seismology, and volcanology, History of the Earth	Rain phenomena, Atmospheric general circulation, Oceanic general circulation	Creation of the universe, Solar system
10-12	High school	Advanced Earth Science	Geodesy, Geophysics, Mineralogy, Petrology, Paleontology, Geological mapping	Synoptic meteorology, aerology, Basic oceanology	Stellar astronomy, Galactic astronomy, Cosmology

14.2.3 Earth Science in "Science" for Junior High School Students

Within the lower secondary school subject "Science", a natural science class dealing with quite basic geology, meteorology, and astronomy, builds on the primary school science classes. In the first year (7th grade), earthquakes and volcanoes are taught in the context of plate tectonics. Meteorological observations, cloud generating processes, and weather in and around Japan, from the perspective of air masses, are the natural science study topics in 8th grade. Finally, students must learn basic astronomy, mainly dealing with our solar system. Study topics in the third year are: physical properties of our Moon and Sun, moon phases in terms of revolution, and diurnal and seasonal changes of constellations related to Earth's rotation and revolution. The phases of Venus are also included, with physical relationships to its revolution around the Sun.

14.2.4 "Basic Earth Science" for High School Students

For some students, one of the goals of upper secondary school is to prepare for university entrance examinations. High schools establish the curriculum, including advanced science subjects, for this purpose. The "Course of Study" has many subjects on all fields of natural science. A high school principal can choose any subjects from those of the national curriculum and specialized science teachers teach their subjects. Basic natural science classes, such as "Basic Physics", "Basic Chemistry", "Basic Biology", and "Basic Earth Science", are widely taught in high school.

"Basic Earth Science" classes are mainly provided for general high school students. In contrast to the junior high school science class basic content on regional phenomena, high school students deepen their knowledge of plate tectonics, volcanism and seismic activity, Earth's evolution, global atmospheric circulation, and origins of the universe.

While practical activities in the science class are common, open-air lessons are rarely conducted due to limited lesson time.

14.2.5 "Advanced Earth Science" for High School Students

After studying basic sciences, students can take advanced science subjects. Advanced science subjects "Advanced Physics", "Advanced Chemistry" and "Advanced Biology" are widely taught in many schools because universities that have science and technology, and/or medicine courses require academic proficiency in those subjects. Hence the subject "Advanced Earth Science", including astronomy, is rarely taught, so that few students learn advance geosciences before entering university.

14.3. Japan Earth Science Olympiad as the Selection Process for IESO Delegations

14.3.1 Three Steps to the Final

The Japanese national selection process for the IESO consists of three steps. First, the preliminary selection is held in various regions. In the case of school year (SY) 2014, 77 test sites were prepared in 42 provinces. A uniform written examination, held in mid-December, is the first step for selection. The students must complete the multiple-choice test in two hours. JESOC has commissioned professors from local universities to conduct the examination on site with local coordinators to help implement the test.

About 2000 students from almost all provinces in Japan applied to take this written test. From this cohort, approximately 60 winners of the initial contest can sit the second exam. The 10 winners from the second stage advance to the finals. JESOC offers some merit awards for overall 1st and 2nd places, 1st place in rock and fossil identification, 1st place among women, and 1st place among junior high school students.

In the final stage, JESOC conducts interviews and group discussions concerning geoscience, in addition to the written exam. JESOC weights English-language skills for the IESO delegates (Hisada et al., 2014), conducting the final exam in English, while the preliminary and secondary selections are in Japanese. Finally, we select four delegates for the IESO based on all components described above.

14.3.2 Examination Content in the First and Second Selection Rounds

Test writers for the preliminary round come from both Earth science and astronomy. JESOC requests the academic community introduce potential writers so that researchers might generate questions about their specific field. For the first written test, students answer questions based on the basic Earth science textbooks and written by the researchers. Except for stellar and galaxy astronomy, any topic of "Basic Earth Science" can be on the test.

The second selection round includes a practical test in addition to the written test. The second stage selection exam is a written test at first-year university level, including long-answer format questions. Geological map reading ability is emphasized on this test as it is very important skill for geoscience research. As geological maps are not taught in high school "Basic Earth Science", most students must learn this by themselves.

14.3.3 Motivating Students

Students who participate in the second selection get a JESO transcript. When they apply for university admission, some schools may admit the student based on their JESO certification.

14.4 Delegate Training for IESO

14.4.1 Summer Camps

JESOC runs training camps twice for the delegates in cooperation with research organizations, such as universities, science institutes and museums. In SY 2014, the two summer camps were conducted for two and three days. The purpose of the training camps are to improve the students' Earth science knowledge and abilities, and develop a mutual understanding among them.

In mid-June, 2014, students went on a two-day field excursion to observe sedimentary rocks. During the tour, the students learned to read geological maps, measure strike and dip of strata, and reconstruct a sedimentary environment. In the evening, astronomical training served to familiarize students with telescopes.

The second summer camp at the University of Tsukuba in late-August, included laboratory investigations of geological samples, such as minerals, rocks, and fossils. Delegate students also received a series of lectures on geology, meteorology, and oceanography.

14.4.2 Remote Training Utilizing Email

The remote training program in preparation for the IESO runs between April and September until just before the IESO. For SYs 2014 and 2015, an assignment was sent by email for students to return completed to instructors in a month. The training team, consisting of two high school teachers and one researcher, instructs students on methods for showing solutions. The purpose of this training process is for students to become familiar with the level expected at the IESO and find their personal weak points, therefore the teaching materials are comprised of past IESO written tests.

14.5 Organization Operation

After observing the first IESO, Japanese researchers determined the IESO provides opportunities to discuss international views and nurture friendships, and incentive to young students (Hisada et al., 2014). The Japan Geoscience Union (JpGU) decided to set up JESOC in 2008. The next year, the committee JESOC incorporated as NPO.

JESOC is in good financial condition because most of the committee's income comes from the national government through the Japan Science and Technology Agency, the same as for other science Olympiads.

14.6 Promoting Earth Science in Japan

Under the updated science curriculum, Earth science student numbers have increased. As a result of JESO activities, the emphasis is now that Earth science education is useful for implementing disaster mitigation measures and thinking about global environmental issues.

To further promote Earth science, JESOC provides research lectures and runs study tours to Earth-science relevant laboratories during the second selection round. This event provides students exposure to up-to-date research results and good opportunities for face-to-face conversations about Earth science.

The 10th anniversary IESO Japan was a good opportunity to make an appeal for Earth science education to the broader Japanese society. On this occasion, JESOC gained recognition and promoted Earth science education among schools in Japan.

14.7 Conclusion

In 2016, the 10th IESO was held in Japan. Young researchers from all over the world talked about our future from an Earth Science perspective, which is always subject to natural disasters. The 10th IESO revitalized the broad importance of Earth science research activities.

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Chapter 15

Earth Science Education in the State of Kuwait

Ibrahim A. Mohammed Ali

Abstract

The State of Kuwait attaches great importance to education. The State Constitution contains an item on education and its gratuitous, from kindergarten to high education.

The Ministry of Education in Kuwait is keen to develop the educational curricula in its schools from time to time to ensure that it keeps abreast of the rapid developments in education in the world. It is also keen on the continuous development of its teachers through continuous workshops and joining courses inside and outside Kuwait, so that the teacher can develop and enhance the different skills of students.

The Government of the country is cares to offer scholarships for outstanding students to study abroad at universities or for higher education institutions.

Teaching of the earth sciences enjoys the attention of the Ministry of Education. Although, the State of Kuwait has poor in geological features, but it has a source of income is essential which is production and exportation of oil, and teaching earth sciences of the fundamentals of exploration and extraction and refining of the oil and it took great interest.

Keywords: Al Rawdatain, Umm Al Aish, Jal-Alzour hills, Ahmadi dome

15.1 Introduction

The educational system in the State Of Kuwait spans 12 years, divided into three stages:

1. Kindergarten (optional): two years, 4-6 years old

2. Elementary: divided into five years
3. Intermediate: divided into four years
4. Secondary (High): divided into three years

In our elementary system, students in grades (1-4) receive continuous evaluation to pass to the next year. In grade five, students take four examinations to pass through to the intermediate stage.

In the intermediate stage, student take four examinations to pass to the secondary stage.

In the secondary stage, students take four examinations to pass through to university studies. A student selects a discipline to study (sciences or literature) in grade 11 and continues on this course in grade 12.

After the secondary stage, the student must pass pre-admittance examinations in mathematics, chemistry and English language to gain admittance to the science faculties.

Earth sciences in State of Kuwait schools are taught in General Science Curriculum chapters from grade 1 to grade 9 and as a separate subject in grade 11. Student do not receive Earth Science education in grades 10 or 12.

Kuwait is poor in geologic features, with the exception of some in Northern Kuwait (Jal-ALzour) and some hills with fold structures and sand dunes in Southern Kuwait (Ahmadi).

Kuwait University sends groups of geology students abroad for field studies to Morocco, Jordan, Oman, and Egypt.

15.2 Earth Sciences content in Kuwait's schools

Grade 1: Very simple and general concepts in "Earth & Sky", climate, and conservation.

Grade 2: Simple concepts about the Earth's crust (rocks, soil and reusable resources); making very simple climate descriptions; seasons; and day and night.

Grade 3: Very simple concepts about Earth's Topography; how rocks form; interactions within rocks and soil; earthquakes and volcanoes; simple advancement of concepts in climate and seasons; and the Solar System.

Grade 4: Changes in Earth's surface: effects of earthquakes and volcanoes on Earth's surface; features of Earth's surface; how water and winds change Earth's surface and resources.

Grade 5: Solar System Movements: rotation of the Earth and its effects; and rotation of the Moon and its effects.

Grade 6: The Changing Earth: Earth's resources (exploring models of Earth's layers, exploring Earth's resources, and protecting clean air); climate; the water cycle; how the Sun affects the climate and what causes climate change.

Grade 7: Earth's Structure: layers of the Earth; Earth's interior; and earthquakes and volcanoes.

Grade 8: Weathering and soils, fresh water, water and its properties, surface and ground waters.

Grade 9: The atmosphere (a blanket of air, its structure, the changing atmosphere, humidity, weather forecasting, climate factors, climate classification) and mineral and energy resources (mineral resources, fossil-fuel resources and alternative energy resources).

Grade 11: Introduction to geology, minerals (formation, and physical, chemical and crystal properties), rocks (igneous rock generation and structures; sedimentary environments, formation of sedimentary rocks, primary sedimentary structures; metamorphism, metamorphic rock textures), mass wasting, secondary structures (faults, folds, and joints), cosmology (formation of the universe, galaxies and star life cycles, and formation of our Solar System), continental motion (continental drift, Plate Tectonic Theory, and implications of plate tectonics), a journey through geological time (life in the past (fossils), the geological timescale, and reading Earth's history), maps (topographic contour maps and geologic maps), oil resources (formation, traps, and oil in Kuwait), and groundwater.

The Earth Sciences Curriculum from grades 1 to 11 is published by PEARSON (Scott Foresman), translated to Arabic and formatted by the Educational Research Center (Lebanon) and coordinated by the Ministry of Education (State of Kuwait).

15.3 The strengths and weaknesses in Earth Sciences in the State of Kuwait

The strength of Kuwait's education stems from continuous Earth Sciences studies from grade 1 to 9. The discontinuity in grades 10 and 12 is the primary weakness. Moreover, teaching Earth Sciences is limited by the shortfall of geological features within Kuwait.

15.4 Selecting Kuwaiti participants for the IESO competition

Preparations start in December with the National Earth Science Olympiad. In this competition, all grade 11 science discipline students begin studying and training in Earth sciences with science activities during school hours. In April, the first test is conducted to select 15 participants from all Kuwaiti schools (Figs 15.1-15.5). A second test in June, following the IESO syllabus, selects the four IESO participants. These four team members spend July, August, and the days of September before the competition training in cooperation with various educational institutions in Kuwait.

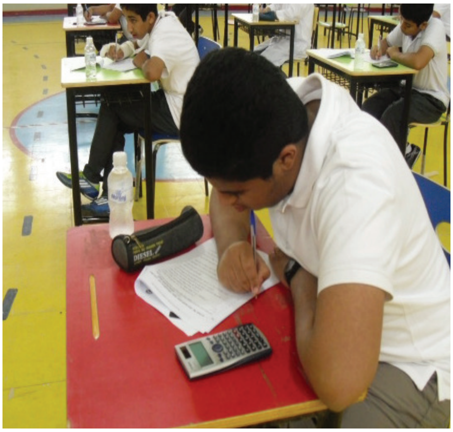

Fig. 15.1 and 15.2 Written test for IESO selection

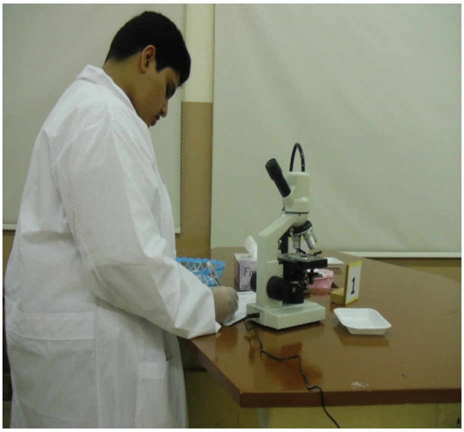

Fig. 15.3 – 15.5 Practical test for IESO selection

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Chapter 16

Earth Science Education and National Selection and Preparation Process for the International Earth Science Olympiad in Malawi

Yvonne Chasukwa Mwalwenje and Elyvin Nkhonjera Chawinga

Abstract

Earth Science concepts in Malawi are taught under a broad discipline of Geography. Geography covers Astronomy, Oceanography, Geomorphology, Geology and Environmental Science. Malawi first entered a team at the International Earth Science Olympiad (IESO) in 2011. The country's national selection process is an integral part of the team's performance at the Olympiad.

The country's education comprises of public and private schools. Private schools are categorized into international and national (Malunga 2001). An objective test is conducted at a cluster to identify participants for a national team. A cluster consists of a maximum of twenty secondary schools (Ministry of Education, 2001). Mentors facilitate all the test processes.

The procedure starts in December of the preceding year with a workshop. Mentors familiarize candidates with the IESO syllabus, including Olympiad regulations and ethics. To cut logistical costs, mentors move across the three regions of Malawi to conduct the selection tests.

Gronlund (1990) asserts that for results to be reliable, professional ethics of validity, fairness and consistence must always be upheld in assessment leading to selection. Similarly, Malawi's IESO assessment has always been effective and has never been affected by opinions, feelings, impressions and any social value. Consequently, such selection process control has assisted the country to identify high caliber students.

However, it is a challenge to select a team that is nationally representa-

tive from both private and public schools. Mentors observe that students from International Private Schools dominate the selection process, as they have best teaching and learning resources. Although public students put effort into the assessment, their background handicaps their success.

Therefore, this paper argues that there is no fairness in the selection of the Malawi IESO team. Unless the playing field is leveled, students from International Private Schools will continually dominate Malawi's IESO team.

Keywords: Malawi Examination Board, International Earth Science Olympiad, Assessment, Mentor, Selection

16.1 Background

Malawi's key interest in Earth Science related concepts dates back to its colonial education system; compulsory Earth Science Education was included in primary and secondary school curricula before independence from British rule in 1964. At the tertiary level, Earth Science is manly offered to Earth Science teachers and those studying geology, astronomy and environmental sciences. In teaching and learning sessions, qualified primary and secondary school teachers are responsible for teaching Earth Science concepts. The assumption is that well trained teachers are more likely to produce successful students.

Hence, Earth Science should be a successful subject in Malawi. Earth Science concepts are taught in the Geography curriculum from primary school for eight years and in secondary school for four, quite often including advanced core concepts. Earth Science concepts in Malawi are found in subjects such as Geography, Agriculture, History and Biology.

In an effort to raise student interest and public awareness of Earth Sciences and to enhance Earth Science learning for Malawian students, the 5th International Earth Science Olympiad (IESO) Local Organizing Committee initiated Malawi participation at the Olympiad. Hence Malawi organized a team that participated at the 5th IESO in Modena, Italy as the first African country to enter a team in 2011.

This paper, therefore, explores Earth Science Education in Malawi. The analysis focuses on the interconnected dimensions of this system, the National Selection and Preparation Process for IESO and, finally, challenges that Malawi faces in the students selection process. In this paper, Geography is used synonymously with Earth Science, as is the case in the Malawi primary and secondary schools.

16.2 National Earth Science Education System in Malawi

Malawi has an 8-4-4 education system, which consists of public and private primary, secondary and tertiary education (Malawi Government, 2001). Geography concepts are introduced from standard (grade) one at primary school. Students enter primary school at six years and continue for eight years, from standard 1 to 8. Common concepts at this age are physical geography of the students' environment and surroundings.

Additionally, Geography is integrated into Social Studies in Malawi primary schools, along with History and Civics. At the end of eight years, pupils write their national examinations for the Primary School Leaving Certificate, which are jointly set, conducted and marked by the Ministry of Education and the Malawi National Examinations Boards (MANEB 2015). Lusungu Msowoya, a teacher at Mwenilondo primary school in Karonga, in the north of Malawi, noted that primary school students perform quite well in Geography during the national examinations compared to languages and pure science subjects. One of the reasons Lusungu proposed for this was that the students are immersed the environment in which they learn and the lessons become tangible when taught. In order for a student to be selected to attend public secondary schools, they must excel at the Malawi National Examinations Board exams. To attend private schools, enrollment is simply a matter of cost.

Malawi Earth Science secondary education has undergone many changes, including adding new topics and dropping others. For a long time since independence, there was a restriction in Malawi secondary schools against teaching Earth Science as one of the core subjects. Nevertheless, this restriction was changed in 1994, due in great part to multiparty political dispensation advancing the right for each student to have freedom of choice to learn the subjects they wish. The perception resulted in making Earth Science one of the elective subjects in the curriculum.

In 2000, the government of Malawi conducted a curriculum review in which Earth Science was revised; some topics were dropped while other new topics were introduced to make the subject more relevant. Some detailed key topics in the areas of geology, astronomy, environmental sciences, and hydrology were among those added. At the same time, the pure geological topic of mining was scrapped.

The curriculum fix was indeed well timed considering the government had recently employed fresh Earth Science teachers, graduating from various universities with geography majors, to augment the new content and assist the old timers in delivering it. It should be noted that qualified primary and secondary school teachers in Malawi are responsible for teaching Earth Science concepts. The assumption is that trained teachers are more likely to produce successful students hence, making Earth Science a successful subject.

Despite this huge curriculum overhaul and coupled with enriched human resource capital, Earth Science did not enjoy the new status assigned to the subject. Many students did not like the subject; they did not opt for Earth Science because it was alleged to present many challenges as a more scientific subject that was branded as a humanities subject. Additionally, the subject faced opposition from related subjects within the humanities department.

Following on from this, students maintain it is more challenging to earn good grades in Earth Sciences, as taught in recent years, than in other newly introduced subjects like Social Studies and Life Skills. As such, learners prefer the new subjects to Earth Science as they believe they are simpler, more relevant, and better address the needs of society (Kadzamira 2001). According to Banda (2000), students further contend that if someone is good at Life Skills they work as a counselor in various organizations dealing with Human Immunodeficiency Virus (HIV) and AIDS issues, while Earth Sciences offers few career paths in Malawi other than teaching.

It should be noted that teaching is perceived very low grade work in Malawi (personal communication, Fidelis Mgowa). Therefore, learners are not inspired to pursue Earth Science amid lean career path options in the near future; they do not see the value of learning Earth Science in the current wake of unemployment for Earth Science specialists. For example, of the 400 practicing teachers who graduated from public Universities in Malawi in 2014, no one is employed by the Malawi government, yet government is a major employer in many sectors. The market cites economic meltdown as the cause, yet graduates from other courses are offered employment by the same marketplace.

In a twist of events, in 2007 many students sat the national Earth Science examination when it became apparent many universities were required to enroll students with good grades in Earth Science. This resulted in many students taking the subject again in hopes of being admitted to university, not because they liked it. Unfortunately, instruction in the subject was at the mercy of the head teacher and if he or she had no interest in Earth Science, it was unquestioned. This created a setting in which some students finished secondary education without learning a single Earth Science concept. Therefore, Earth Science received very little attention during this era.

However, the Earth Science policy has since changed since 2014 when

Earth Science assumed its prior status as a core subject. Now, it is taught four times during the forty periods per week. In Malawi, students in secondary schools sit for two National Examinations: a Junior Certificate Examinations (JCE) at form 2 and a Malawi School Leaving Certificate (MSCE) at form 4. The performance of Earth Science at MSCE descended over the years, reaching a low of 58.64 percent in 2010, from 73.34 percent in 2006 (Malawi National Examination Board, 2015). There is a clear-cut boundary between public and private schools, with private schools excelling over public schools.

Very few practicing teachers have an Earth Science degree from university. In addition to those coming through education departments, graduates come from Earth science, geology, hydrology and soil sciences, meteorology, and astronomy departments rounding out the numbers of Earth Science alumni in Malawi.

16.3 International Earth Science Olympiad in Malawi

Malawi was privileged and humbled to be the first African country to enter a team at the 5th International Earth science Olympiad (IESO), 5-14 September 2011 in Modena, Italy. The Government of Malawi extended gratitude to the Local Organizing Committee in Italy chaired by Roberto Greco for meeting all logistical and financial support for the team to participate in Italy. The support ranged from airfare, accommodation, airport pick up at the venue as well as upkeep. The Malawi team met the requirements stipulating teams consist of four competing students, an alternate, and mentors. The team that started off at Kamuzu International airport on 4th September 2011 comprised of 6 participants. The team had two mentors, Elyvin Nkhonjera Chawinga and Yvonne Chasukwa Mwalwenje. Elyvin is an Earth Science specialist currently working with Oxfam Malawi as a Coordinator for extractive Minerals. Yvonne is an Earth Science educator at Bwaila secondary school, a public school in central Malawi in Lilongwe.

The team had good gender representation: two girls and two boys namely Thembi Sibale, Faith Chibonga, Goodson Kumwenda, and Joseph Mhango. All four participants were high school students. Joseph, Thembi and Faith came from Kamuzu Academy international school, which is a prestigious international private school, while Goodson came from Bwaila Secondary school, one of the lowest resourced large public schools in the capital Lilongwe. All the students travelling to Italy had robust knowledge and understanding of Earth Science. At its first IESO, Malawi won a Bronze medal and two other participation prizes. After Italy, Malawi continued to participate in two other IESOs, India (2013) and Brazil (2015) in an observational role, as financial challenges precluded bringing teams on both occasions.

16.3.1 National Selection

It is not an understatement that most Malawians only first heard about the IESO in 2011 when the 5th Local Organizing Committee in Italy extended an invitation to Malawi to participate at the Olympiad. This assertion was evident when the mentors began organizing and selecting a national team, which required civic education for better understanding of the concept. The public generally did not understand the idea of Earth Science teachers as a stand-alone classification. It was most daunting to help the parents understand, as they had never heard of the IESO. The worst scenario came when a parent of a selected student went overboard and assumed the mentors were playing tricks and wanted to abduct the students.

16.3.2 The selection process

Malawi, the first African country to enter a team at the 5th IESO in Modena, Italy in 2011, has a national selection process that is vital to the success or failure of the country's team at the IESO. If the process is faulty, the Olympiad results will be out of order as well. To avoid such a scenario, the Malawi IESO chapter, headed by Elyvin Nkhonjera Chawinga and Yvonne Chasukwa Mwalwenje, takes charge of developing and administering the national selection and preparation processes for IESO in Malawi.

It should be noted that the education system in Malawi comprises both public and private schools. Private schools are further categorized into international and national schools (Malunga 2001). It is Elyvin and Yvonne's duty to ensure both systems catered for. Thus, an objective test is conducted at clusters across the country to identify potential national team participants. A cluster consists of a maximum of twenty secondary schools (Ministry of Education, 2001).

The national preparation and selection process for the Malawi team starts in December of the preceding year. Mentors and other Earth Science related teachers are involved in formulating and moderating the exam papers. The paper covers a combination of astronomy, oceanography, geomorphology, geology and environmental science. There are no stand-alone disciplines for each area, rather all are taught under the broad discipline of geography.

The process starts with a three-day course wherein mentors familiarize candidates with the IESO syllabus. Mentors employ engaging techniques to teach challenging concepts from the IESO syllabus to help students attain deep understanding, while training candidates in efficient study techniques. The mentors also remind the candidates of Olympiad regulations and ethics.

Mentors move across the three regions of Malawi (South, Central and North) to conduct the selection test. This is less expensive than moving students to one central location for the assessments due to logistical challenges, for example finding accommodation and providing upkeep.

For the written examinations, twenty students are examined in one room with four invigilators supervising them. Normally, three hours is the maximum time students are given to write the exam depending on the number of questions and content complexity. Questions are set from simple to complex using Blooms taxonomy model available on http://www.ion.uillinois.edu/resources/tutorials/assessment/bloomtaxonomy.asp . To ensure the validity and reliability of the examinations, the papers are written on the same day and time across the country. Team marking is conducted at one center, two days after the examinations. Conveyor belt marking is used for the selection examinations in Malawi. Conveyer belt system of marking ensures examiner marks only a few questions, promoting fairness and expedience.

To make the process more responsive to the needs and aspirations of the Malawi students, the national selection process attempts to conduct tests that reflect both the course content (geography, biology and agriculture) and that of the orientation prior to the process. When conducting the selection test, mentors and the cooperating Earth Science teachers ensure that instructions on the papers are well written and closely followed. This is crucial for student success in the examinations. Gronlund (1990) asserts that assessment instruments must be consistent and satisfactorily measure what they intend to measure. Thus, for results to be reliable, the professional ethics of validity, fairness and consistency must always be upheld in the pre-selection assessments.

The team prepares model answers in advance. The tests given out by the IESO Malawi Chapter are objective and effective, uncompromised by opinions, feelings, impressions, or any social values. Consequently, such a national selection process control has assisted the mentors to identify high caliber students for the Olympiad since 2011.

16.3.3 IESO Advantages and its Influence on Education in Malawi

The merits of Malawi participating in IESO cannot be underestimated. One of the most frequently raised advantages, which is regarded by many as the key foundation on which IESO is built in Malawi, is the number of students enrolling in the course over the past five years. There is a tremendous increase in the number of students now studying Earth Science compared to 2005-2010. The high number is attributed to the introduction of IESO in Malawi. Chiku Osman, a student at Bwaila secondary school, reported that initially there was no motivation for one to work hard in Earth Science class. Now that he has hopes of flying to an international Olympiad one day, he says he has a reason to work hard and commit to that hope.

Secondly, these international meetings are an eye opener to contemporary Earth Science teaching and helped both students and mentors acquire relevant Earth Science technical knowledge and skills. Despite enrollment in various universities both nationally and internationally, all the students who travelled to Italy appreciated the time they travelled across continents. For the mentors, participating in the Earth Sciences teachers program in India gave Yvonne a greater perception on interactive Earth Science teaching methods. She has since gone on to train 17 teachers at her school and neighboring schools the methods she learned at the IESO. Because of the IESO experience, she also presented a paper at the Earth Science Information for Teachers workshop in Austria, "Role of Grassroots Environmental Literacy: The case of water security at Bwaila Secondary School, Malawi". The organizers of the conference were honest enough to explain they invited Yvonne because of her experience with IESO. Against such a backdrop, IESO deserves attention and honor if Malawi is to make strides in Earth Science.

In conclusion, the IESO has also helped expand students' understanding in Earth Science and ever since, it has provided the mentors and collaborating teachers with the necessary skills to creatively address Earth Science challenges and develop sound Earth Science teaching skills.

16.3.4 Challenges Malawi Faces for National Team Selection

It is a challenge to select a national team that is representative of the range of students in Malawi. The disparate capacity public and private schools have for teaching and learning Earth Sciences creates an imbalance. Public schools are disadvantaged by inadequate teaching and learning resources and materials, libraries, and technology. Not surprisingly, mentors observe that the most successful students in the selection process are those from International Schools. Empirical data from the past five years shows private schools have a 75 percent lead over public schools. In 2011 and 2012, private school had a 75 percent pass rate. In 2013, private schools swept 100 percent. The trend has continued over the past two years with private schools running the board.

Consequently, mentors intimate that this is most likely because International Private Schools have the best teaching and learning resources. Although public students appear to put much effort into the assessment, their formative experiences challenge their success. Therefore, this paper reveals that there is no fairness in the selection of Malawi IESO team. The unfairness comes in because the candidates that sit for IESO examinations are drawn from both private international schools and public local schools. The candidates from the international schools have an edge over their counterparts from the local public schools because their schools have better teaching and learning facilities making them readier for the examinations. Unless the playing field is leveled, students from International Private Schools will continue to dominate the Malawi IESO team.

Furthermore, the Malawi IESO Chapter is handicapped by poor funding. This is primarily due to the unappealing status quo of Earth Science established during colonial rule in Malawi, placing the subject in humanities rather than science. In Malawi, humanities subjects do not capture worthy attention. The history of Earth Science curriculum and within Malawian society also haunts the subject, dissuading potential donors and even educational stakeholders from supporting IESO. Rather, they direct their backing to the Mathematics Olympiad because it is a science subject, which draws more attention in Malawi.

In conclusion, the system of administering an examination to identify students to participate at IESO facilitates that brighter students are identified. Since both international private schools and local public schools sit for the same examinations, it favors the former since they have better learning and teaching facilities compared to the later. Therefore, IESO examinations should be categorized targeting international private schools and public schools to provide equity for access to IESO competitions.

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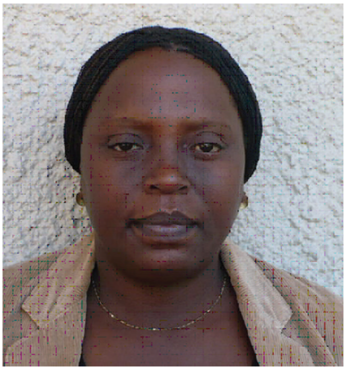
Yvonne Mwalwenje



Holds a Bachelor of Education (Geography) from Domasi College of Education in conjunction with Chancellor College, a constituent college of the University of Malawi. Yvonne is a mentor and member of the Jury for Malawi's International Earth Sciences Olympiad, Member, International Geoscience Education Organization, and Councilor, African Network for Geo Education. Yvonne mentored Malawi, the first African team to enter the International Earth Sciences in 2011 in Italy, which won a Bronze medal.

With 23 years of experience with progressive teaching and leadership responsibility in Malawi, she seeks to direct her skills and knowledge to the developing a generation of Earth Sciences students capable of creating a more sustainable Science world, and strengthening initiatives, programs, and organizations that empower people and communities. Yvonne is married to Fidelis Chasukwa. The family is blessed with three children Steria, Fidel and Tumpale. *Department of Humanities, Bwaila Secondary School, P.O. Box 410, Lilongwe. Malawi. E-mail: yvonnechasukwa@gmail.com*

Elyvin Nkhonjera

A young environmental geoscientist in Malawi currently working with Oxfam in Civil Society as an Extractive Industry Program Coordinator. She has 10 years' experience managing Extractive Industries Governance projects in Malawi. She studied her MSc in Environmental Sciences at the University of Malawi Chancellor College, where she focused of Environmental Geology and Geohazards. She also holds a BSc in Natural Resources Management from the University of Malawi, Bunda College of Agriculture. Elyvin is a member of the Young Earth Scientists Network, she is one of the founders of the network and served as a general secretary from its establishment in 2008 to 2009 and then as a chairperson for the outreach committee until 2012. Elyvin is also a Member of the International Earth Science Olympiad as a mentor for the Malawi team. *Oxfam in Malawi; Private Bag B331, 30735, Lilongwe 3, Malawi. E-mail: elyvinnkhonjera@gmail.com*

Chapter 17

Earth Sciences Education from Primary School to University: Case of Morocco

Ezzoura Errami, Nasser Ennih, Yamina Bourgeoini, Abdellah Lakhloufi

Abstract

A review of the official Earth sciences education programs in Morocco shows these sciences are taught from primary to secondary schools with general content including environment, water resources and their management, soils and agriculture, external and internal Earth geodynamics, and related activity. However, the hours dedicated to these sciences are generally lower than for Life Sciences, to which it is linked in all curricula. Reviewing the curricula for Life and Earth sciences teacher training's programs and regional Earth Sciences Education meetings reports in Morocco, shows that these sciences are taught by teachers who are primarily trained in Life Sciences. To help to improve this situation and make teachers and students better appreciate Earth Science disciplines, we propose: separate training for teachers in Earth and Life Sciences, increasing instruction hours for Earth sciences in the curricula for both teachers and students, introducing more practical work in teacher training and student teaching, and providing more teaching materials and necessary logistics to facilitate field trips.

On the other hand, the Moroccan Higher Education Institutions (HEI), including universities, engineering and technical schools, offer curricula that covers all Earth science disciplines with more practical work and field trips. However, students face a major linguistic obstacle, not specific to Earth Sciences, which the new educational system reform seeks to solve by returning to French as the teaching language for sciences in secondary schools. To help improve instruction in some Earth science disciplines, HEI are creating technological platforms in each university to provide students with high performing scientific and technical equipment.

Keywords: Earth Sciences, education, primary and secondary schools, universities, Morocco

17.1 Introduction

The reconstruction of Earth's long and complicated history since its formation approximately 4.56 billion years ago and comprehension of how its systems work are continuous challenges for scientists. Earth Sciences or "Geosciences" are all sciences applied to studying our planet Earth and meet these challenges. Earth Sciences cover a very broad field of sciences, since they include studying all geological phenomena related to our planet from its surface to its deepest parts. They bring together several complementary and sometimes interpenetrating disciplines, such as mineralogy, petrography, geochemistry, paleontology, stratigraphy, sedimentology, tectonics, hydrogeology, geophysics, metallurgy, remote sensing, geo-heritage, geo-environment, *etc*. These sciences play an important role in all socio-economic approaches for a sustainable world. Environmental issues, energy needs, and natural disaster management cannot be handled properly without multidisciplinary geoscientific studies. Earth Sciences knowledge is necessary to *i*) minimize the risk of natural disasters such as earthquakes, floods and landslides; *ii*) preserve and improve our local, regional or global environment; *iii*) adapt to climate change, *iv*) preserve and improve the quality of our soils, and *v*) provide access to safe drinking water.

To achieve the objectives mentioned above, Moroccan geoscientists should have appropriate skills to implement these sciences to help solve problems, meet challenges and take advantage of the country's natural resources for sustainable human and socio-economic development. In Morocco, Earth Sciences education has evolved over time through different curricula introduced during numerous educational system reforms. The aim of this paper is to give an overview of Earth Sciences education in the Moroccan educational system, from primary school to higher education. To meet this objective, we analyze official documents from the Ministry of National Education, Professional Training, Higher Education and Scientific Research, which is the responsible for public education organization and development. In this capacity, the ministry develops curricula and teaching methods, supervises school textbook conception, and ensures teacher and administrator training. It also supervises private education, ensuring that its structure, curricula and teaching methods conform to those of the public sector (*Aperçu sur le système éducatif marocain*, 2004).

As teaching quality is related to a teacher's training, we analyzed the training curricula for secondary school Earth Sciences teachers. This analysis is coupled with unpublished reports from two national Earth Sciences education meetings, wherein teachers from secondary schools and universities met.

To provide an overview of Earth Sciences in Moroccan higher education institutions, we analyze universities offerings based on the official websites of the Sciences, and Sciences and Technology Faculties, engineering and technical schools. To complete our data, we interview those responsible for training and administration.

17.2 Earth Sciences Education in Morocco

Since Morocco's independence in 1956, its educational system has undergone numerous reforms influenced by demographic, political, social, and economic factors. The first reforms were implemented to meet the social expectations of a population that attaches great importance to the school as an instrument of social rise. These reforms occurred at all levels of the Moroccan educational system, with the objective to improve education and training quality at the program level.

The Moroccan educational system is structured, from kindergarten to higher education, as show in Table 17.1.

Tab. 17.1 Terminology and age ranges in the Moroccan educational system

Type of schools/ institutions		Ages in years	Duration	External examinations taken at end of each phase
Kindergarten	Early years	4-5	2 years	-------
Primary school	Infant	6-7	2 years	Certificate (*Regional curriculum tests*) in French, Arabic and Math
	Junior	8-11	4 years	Certificate (*Regional curriculum tests*) in French, Arabic and Math
Secondary school	Lower secondary (*College*)	12-14	3 years	Certificate (*Regional curriculum tests*) in French, Arabic, Math and Sciences
	Upper secondary (*Lycée*)	15-17	3 years	Baccalaureate (N*ational curriculum tests, General certificates of secondary education*)
University (License, Master, Doctorate -*LMD* system)		18-20	3 years	License

(From *La Charte nationale d'éducation et de formation*, 1999)

17.2.1 Earth Sciences Education in Primary Schools

Natural Sciences are introduced from the first year of primary school as part of the scientific activities instruction during two 45-minutes sessions per week for the whole school year. The concepts discussed in these levels are directly related to students' daily life and aim to stimulate their scientific curiosity. This teaching includes a set of science subjects mainly related to physics and life sciences. However, Earth sciences chapters are very limited and aim to introduce students to water and nature, soils and astronomy (*Guide Pédagogique de l'Enseignement Primaire; Livre blanc, 2002*). This is minimal compared to the other scientific concepts, including Life sciences, covered (Table 17.2).

Tab. 17.2 Earth Sciences in primary school

Primary school	Earth Sciences chapters/Total scientific activity chapters	Content
First year	1/8	Water and Nature
Second year	0/8	----
Third year	0/8	----
Fourth year	1/10	Water and Nature
Fifth year	1/8	Nature
Sixth year	2/5	Soils and Astronomy

(*Guide pédagogique de l'enseignement primaire*)

17.2.2 Earth Sciences Education in lower Secondary School (College)

College in Morocco is the first three years of secondary school (Table 3). Earth science (geology) is only taught in the first two years of Life and Earth Sciences at this level, with four of the six modules dedicated to biology (*Les orientations éducatives et les programmes relatifs à l'enseignement de la matière "Sciences de la Vie et de La Terre" au collège*, 2009).

Earth Sciences Education in First Year College. The official program of Life and Earth Sciences in First Year consists of two units taught for two hours per week (Table 3). Only one semester is dedicated to Earth Sciences, with a focus on Earth's external geodynamics. It introduces the historical dimension of geology and the concept of geological time. It covers basic knowledge about water resources and their importance in daily life. The class dips into sedimentary processes, sedimentary rock formation and basic classification, paleontology, and lithostratigraphic scales. Students are taught field methods, such as how to use a topographic map, making observations, note taking, how to measure the thickness of sedimentary strata, how to recognize and classify different sedimentary rocks and fossils, sample collection, and ultimately writing up all of this information into a field trip report.

Earth Sciences Education in Second Year College. The second-year Life and Earth Sciences program continues on from the first-year program, shifting the focus mainly to Earth's internal phenomenon. One of the two semesters is devoted to internal geodynamics (Table 17.3). The content introduces Earth's internal structure and the Theory of Plate Tectonics with its related activity (mountain formation, earthquakes, magmatism, and tectonic deformation). The program also includes a field trip focused on the module content at a location where students will practice the same techniques learned on the field trip the previous year.

Earth Sciences Education in Third Year College. Life and Earth Sciences consist of two units totally dedicated to Life Sciences (Table 17.3), which constitutes a gap in the Earth Sciences curricula.

17.2.3 Earth Sciences Education in Upper Secondary School

The secondary school in Morocco is a three-year phase of specialization (Table 17.3). After succeeding in their college curriculum, students choose between Humanities, Sciences, or "*Taalim Al Assil*", with one year in a common core (Table 17.3). The second and third year of upper secondary school are called first-year and second-year baccalaureate, respectively (Table 17.3). Those who choose Sciences spend the first year of secondary school in a common core where they study all scientific disciplines. After that, their specialization begins in the first-year baccalaureate where they select either the Experimental or Mathematical Sciences series. In the second-year baccalaureate, Experimental Sciences students choose either Life and Earth Sciences, Physical Sciences, or Agricultural sciences. However, Mathematical Sciences students may continue their curricula in the same field or change to the Physical Sciences series. Those who choose Humanities or "*Taalim Al Assil*", continue their curriculum in the same discipline. It is important to note that "*Taalim Al Assil*" is Arabic for "original education"; it is specifically Islamic instruction.

Earth Sciences Education in the First Year of Secondary School (Common Core). In the common core of Sciences, students study all scientific disciplines with Life and Earth Sciences constituting three hours per week for the whole school year (Table 17.3), two units (51 hours each) are dedicated to each Life Sciences and Earth Sciences (*Les orientations éducatives et les programmes relatifs à l'éducation de la matière "Sciences de la Vie et de la Terre" au lycée*, 2007). The latter begins with a field trip wherein the students must learn field work techniques and are introduced to an ecosystem. The curriculum incorporates environmental sciences, focused on ecosystems, soils, and climate and their relationship to living beings, the flow of matter and energy into the environment, and environmental equilibria. In the Humanities and "*Taalim Al Assil*" cores, the Life and Earth Sciences program consists of two units delivered for one hour per week all year dedicated totally to Earth Sciences (Table 17.3). The first unit consists of seventeen hours focused on water use and pollution, water reserves and drinking water, and the water cycle. The second unit dedicates the same time to humans and their environment. It focuses on aspects of environmental disequilibrium, environmental protection, and environment and health.

Earth Sciences Education in the First Year Baccalaureate

Experimental Sciences Series. In this series, Life and Earth Sciences consist of four units taught four hours per week (Table 17.3). Only one unit is dedicated to Earth Sciences and is focused on external geological phenomena. The content guides students toward understanding paleogeographical maps and reconstructing the geological histories of sedimentary phosphate and coal basins using stratigraphic principles, the lithostratigraphic scale, and stratigraphical hiatuses.

Mathematical Sciences Series. In this series, Life and Earth sciences are taught two hours per week with two units (Table 17.3). The unit dedicated to Earth Sciences is focused on external geological phenomena with its content and time allotment exactly the same as the experimental science series described above. The ratio of Earth Sciences to Life Sciences is different, however (Table 17.3).

Humanities and "*Taalim Al Assil*" series. For both series, Life and Earth sciences are taught one hour per week with two units entirely dedicated to Life Sciences (Table 17.3).

Earth Sciences Education in the Second Year Baccalaureate

Life and Earth Sciences Series. The program consists of six units taught six hours per week (Table 17.3). Only one unit from a total of six is dedicated to Earth Sciences, and is focused on geological phenomenon related to mountain belt formation in the context of plate tectonics.

Physical Sciences Series. In these series, Life and Earth Sciences consist of four units taught four hours per week, with only one unit dedicated to Earth Sciences (Table 17.3), composed of the same content as the Life and Earth Sciences series.

Agricultural Sciences Series. Life and Earth Sciences consist of three hours per week with two units, only one of which is dedicated to Earth Sciences (Table 17.3) focusing on water resources management and improving agricultural production.

Mathematical Sciences Series (Option A). Life and Earth Sciences consist of two units dedicated to Life sciences for two hours per week (Table 17.3).

Tab. 17.3 Credit hours of Earth Sciences in Morocco's secondary schools

	Years	Series		Credit hours			Hourly volume per week	Remarks
				Life and Earth Sciences	Earth Sciences			
Lower secondary school (college)	1st year			68 h	34 h	50%	2 h	
	2nd year			68h	34h	50%	2h	
	3rd year			68 h	0 h	0%	2 h	
Upper secondary school	Common cores	Sciences		102 h	51h	50%	3 h	
		Human Sciences		34 h	34 h	100%	1h	Same content
		Taalim Al Assil		34 h	34h	100%	1h	
	First year baccalaureate	Experimental Sciences		136 h	34 h	25%	4 h	Same content
		Mathematical Sciences		68 h	34 h	50%	2 h	
		Human Sciences		34 h	0 h	0%	1 h	Same content
		Taalim Al Assil		34 h	0 h	0%	1 h	
	Second year baccalaureate	Experimental Sciences	Life and Earth Sciences	204 h	34 h	16,66%	6 h	
			Physical Sciences	136 h	34 h	25%	4 h	
			Agricultural Sciences	102 h	28 h	27.45%	3 h	
		Mathematical Sciences	Mathematical Sciences (A)	68 h	0 h	0%	2 h	

(*Les orientations éducatives et les programmes relatifs à l'enseignement de la matière "Sciences de la Vie et de La Terre" au collège*, 2009 ; *Les orientations éducatives et les programmes relatifs à l'éducation de la matière "Sciences de la Vie et de la Terre" au lycée*, 2007)

17.3 Training Life and Earth Sciences Teachers

The "*Ecole Normale Supérieure, ENS*" institutions train Life and Earth Sciences teachers for upper secondary teaching. Initially attached to the Ministry of National Education and designed to train graduate teachers, Morocco's six ENS joined the universities in 2010 and now enjoy the status of higher education institutions with regulated access. The pedagogical architecture of the training offered by these institutes, was completely redesigned to fit with the License/Master/Doctorate (LMD) system adopted within Moroccan universities. The training offered by these institutes is diverse nationally and culminates with a professional license in Education, equivalent to the Bachelor's Degree in the Anglo-Saxon education system. These institutes aim to train candidates aspiring to teach Natural Sciences and prepare them for the examination to access the Regional Centers for Education and Training (*Centres régionaux des métiers de l'éducation et de la formation* [C.R.M.E.F]) and Master's degrees.

The majority of courses taught at these institutes are education focused and therefore reflect their specific vocation. These courses cover a broad range of disciplines from humanities to sciences and technology. At each FUE (*Filières Universitaires d'Enseignement*), pedagogical course work occupies an average of 15 to 30 percent of the total study hours, with the remainder dedicated to the specialization discipline. Student recruitment into the FUE specialization in Life and Earth Sciences is done either from semester 3 (S3) or 5 (S5). In the case of the courses with access to S3, Earth Sciences consists of four modules of the total twenty one modules. Professional licenses do not follow a national curriculum; the ENS are free to design their curricula according to their regional needs. Table 17.4 compares the content of general Earth Sciences modules as taught in Marrakech and Rabat.

Tab. 17.4 Examples of Earth Sciences courses found in training programs for upper secondary school Life and Earth Sciences teachers.

ENS	Semester 3	Semester 4	Semester 5	Semester 6
Rabat	Petrography and Structural geology	Analysis and interpretation of geological elements	Internal and external geodynamics Paleogeography	Applied geology
Marrakech	Sedimentary processes and stratigraphy Endogenous geology	Rock deformation and structural geology	Mining geology and geo-heritage of Morocco	----

These courses aim to deepen students' understanding of internal and external Earth geodynamics developed during the first year (Semester 1 and 2) of university, and also to give them an overview of Morocco's geology. These courses are completed in semester 6 by micro-teaching sessions and reporting on subjects closely related to the didactic aspects of geology teaching.

17.4 Earth Sciences in Higher Education

Morocco has thirteen public universities with open access, twelve of which host Earth Sciences departments within their Faculties of Sciences or Science and Technology. In addition to universities, Earth Sciences are also taught in engineering and public technical schools, with limited access based either on marks or on marks and examination. These higher education institutions (HEI) are under the umbrella of the Ministry of National Education, Professional Training, Higher Education and Scientific Research or the Ministry of Energy, Mines and Sustainable Development.

Higher Education in Morocco has undergone several structural and institutional educational reforms since 1970 *(La charte nationale de l'éducation et de la formation, 1999; La loi 01-00 portant sur l'organisation de l'enseignement supérieur, 2000; Programme d'urgence "2009-2012", 2009).* The new reform, initiated in 2000 and started in September 2003, aims to harmonize the university curriculum with European standards in order to facilitate the mobility of Moroccan students abroad as well as mobility between disciplines and training offered in Morocco. Since then, higher education is organized into semesters composed of teaching units adopting the LMD system (Bologna system). This system consists of three years or six semesters (Bac+3) allowing students to continue to Master's (Bac+5) and/or PhD (Bac+8) degrees. Earth Sciences teaching in the Faculty of Science follows the same reforms adopted nationally.

In the previous system, the Bachelor's (*Licence*) in Earth Sciences was achieved in four years, where the specialization in Earth Sciences began from the first year of the second university cycle (G3, *G means geology*), with 50 percent geology and 50 percent biology courses. The second and last year of the Bachelor's (G4) is more specialized in Geology with only one biological course. It is important to note that the content does not reflect a purely geological specialization. However, under the new reform, a Bachelor's in Earth Sciences is attained in three years instead of four, with a common first year for Life and Earth Sciences. Specialization begins in the second year, when students take only Earth Sciences courses. The 1st and 2nd semesters of the first year introduce students to internal and external Earth dynamics with one module per semester, while in 2nd and 3rd year, students acquire most of the necessary fundamentals in the various Earth Science disciplines. This is the case for all Moroccan universities, with elective modules filling out in the last semester depending on their regional needs.

Earth Sciences are also included in curricula for engineering and technical schools that train engineers in hydro-geotechnical applications, environmental and industrial safety, agronomy and agricultural economics, environmental and natural resource management, Geographic Information Science, meteorology, hydraulic and civil engineering, mineral exploration, natural resources exploitation and industrial waste processing, and construction. The Mines Institute trains technicians and specialized technicians for two or four years after the baccalaureate in applied geology in mines and quarries.

In summary, the analysis of curricula offered by the Moroccan HEI, including universities, engineering and technical schools, shows the richness and diversity on offer, covering all Earth Sciences disciplines. However, some HEI lack scientific and technical equipment (Chakib, 2014; Chakib et *al*., 2015).

17.5 Professional Development Available to Life and Earth Sciences Teachers

During the last years, two regional meetings were organized between secondary school teachers and university lecturers in Morocco. The outcome of these discussions showed that most Life and Earth Sciences teachers in primary and secondary schools received little Earth Sciences education of their own, with almost no practical work or fieldwork, which means they lack critical geological knowledge, and have not mastered numerous geological concepts. This means they are not confident teaching these sciences. To teach Earth Sciences, they typically only use textbooks, prepared under the guidance of the Ministry of National Education, Professional Training, Higher Education and Scientific Research and produced by different private companies, with almost no additional Earth Science-specific teaching materials. The books are usually bought by students, however, to encourage education in rural areas, the state provides all books for free.

The ministry rarely provides professional development courses in Earth Sciences. Most participants of these meetings reported that their background, confidence and motivation to teach Earth Sciences is very poor. An unmotivated teacher automatically transmits his or her lack of motivation to the students, which negatively affects their interest and achievements in this field. This is confirmed by Chmanti-Houari et al. (2016). Adding to that, a review of Earth science content within Life and Earth sciences textbooks adopted in Morocco showed a wide range of Earth Sciences concepts are inadequately designed in primary and secondary school curriculum. These indicators suggest that Earth Sciences education in Morocco can be improved by better training for teachers and a complete textbook review by Earth Sciences specialists working closely with science education specialists and school teachers.

17.6 Support for Earth Sciences Teachers

Local and timely support for Earth Sciences teachers, specifically geology, is provided by voluntary Earth Science lecturers. Since 2013, promotion and support for Earth sciences education is also provided by the African Association of Women in Geosciences (AAWG) and the African Geoparks Network (AGN) in collaboration with numerous national stakeholders, especially the Faculty of Sciences of Chouaib Doukkali University of El Jadida, through their activities. Their "Day of Earth Sciences in Africa and Middle-East" (DESAME) aims to increase awareness about the role Earth scientists could play to help build a more peaceful, healthier and wealthier continent. Numerous activities, such as conferences, workshops, cultural activities, and geological exhibitions are conducted to celebrate DESAME each year. More than 3,000 students from different primary and secondary schools and universities in Casablanca-Settat and Marrakech-Safi administrative regions participated in these activities.

17.7 Discussion and Conclusion

Analysis of the Ministry of National Education, Professional Training, Higher Education and Scientific Research's official documents related to Earth sciences education in primary and secondary schools shows that all students from the age of 6 to 18 have Earth Sciences in their educational curricula. The programs' content covers numerous areas including environment, water resources and their management, soils and agriculture, Earth's external and internal geodynamics, and related the magmatic, metamorphic and tectonic activity. The program also includes relevant field trips. However, the hourly percentage of Earth sciences is generally lower than Life sciences, to which it is closely linked in all curricula, and it is different from one educational level to another and from one specialty to another. But the major problem, at almost all educational levels, is that field trips are often not taken due to logistical problems and other challenges (Lamarti et *al*., 2009). Field trips are a critical tool in Earth sciences teaching, with numerous studies showing their benefits to students and teachers by encouraging critical thinking, improving long-term knowledge retention, encouraging positive attitudes towards science, and increasing scientific curiosity, motivation and self-confidence (Marras Manner, 1995; Davis, 2002).

Nevertheless, it is important to note that Earth sciences are also a part of the geography curriculum primary and secondary school students. However, approximately 15 percent of all students in Morocco are enrolled in private schools (*L'éducation nationale en chiffre, 2015-2016*). These follow the same system as public schools, but incorporate additional courses borrowed from Life and Earth sciences books adopted in France.

Regional meetings focused on Earth Sciences Education in Morocco showed that teacher Earth sciences training is inadequate for what it is required of them. Earth sciences are taught by teachers who are mainly trained in Life sciences.

To help to improve this situation and help teachers and students better appreciate Earth sciences disciplines, it is necessary to: *i*) train teachers in Earth Sciences separately from Life Sciences, which provides specialized teachers in both disciplines; *ii*) increase the hours dedicated to Earth sciences in the curricula for both teachers and students, making it at least equivalent to the time allocated to Life sciences; *iii*) introduce more practical work for primary and secondary students and teacher's training to help them easily understanding geological concepts, including deep time and space; *iv*) provide more teaching material such as rock samples, minerals, fossils, and others educational tools; *v*) integrate more New Information and Communication Technologies in Earth sciences teaching; *vi*) and provide the necessary logistical support to facilitate programmed field trips.

On the other hand, the Moroccan HEI offer curricula incorporating all Earth science disciplines and the instruction includes more practical work and field trips to local geological areas in Morocco. However, transferring scientific knowledge to students faces a major linguistic obstacle as primary and secondary school science education is in Arabic, whereas it is taught in French at the HEI. That problem will be solved by returning to French instruction for primary and secondary school sciences. Teaching Information and Communication Technologies requires ever more space in Moroccan higher education in general and in Earth sciences in particular, however, some HEI lack high performance scientific and technical equipment, which negatively affects practical teaching for some Earth science disciplines (*e.g.* geochemistry, isotope geochemistry and geochronology). This situation will be solved by creating technological platforms in each university, which is work in progress.

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Chapter 18

Earth Science Education in New Zealand

Glenn Vallender

Abstract

This chapter describes the general educational structure in New Zealand with a brief history of New Zealand qualifications and the development of the National Certificate of Educational Achievement (NCEA). NCEA is a standards based assessment system which replaced a wholly norm referenced external examination system in 2003. NCEA is currently (2018) under a major review by the Ministry of Education and the Qualifications Authority. Changes will be phased in from 2020. This has had a major impact on geoscience in the national science curriculum, firstly by requiring an equal status to other sciences and then a general decline. Statistics are given documenting this decline in student numbers. Main achievement standards which relate to the geosciences are described. It is important to note that the NCEA assessment system is derived from the national curriculum. Assessment may drive pedagogy but is not the curriculum. School enrrolment is compulsory from age 6 to 16.

Key Words: NCEA, Geoscience, Achievement standards, School sectors, School types

18.1 The New Zealand School System: A Summary

New Zealand today has an education system divided into primary, secondary and tertiary sectors controlled by the Ministry of Education (http://www.education.govt.nz/ministry-of-education/). The roots of this system are British and French colonialism. National qualifications are administered by the New Zealand Qualifications Authority (NZQA) (http://www.nzqa.govt.nz/), who receive general policy and curriculum advice from the Ministry of Education. Table 18.1 summarizes relationships for schooling in New Zealand.

Tab. 18.1 The New Zealand Education system

Year Level	School Sector	Mainstream School Type	Typical Student Age	National Curriculum level (The NZ Curriculum, 2007)	National Qualifications
1	Primary	Full Primary	5/6	1	Nil
2			6/7	1	Nil
3			7/8	2	Nil
4			8/9	2	Nil
5			9/10	3	Nil
6			10/11	3	Nil
7		Intermediate	11/12	4	Nil
8		Intermediate	12/13	4	Nil
9	Secondary	High School	13/14	5	Nil
10			14/15	5	Nil
11			15/16	6	NCEA level 1
12			16/17	7	NCEA Level 2
13			17/18	8	NCEA Level 3
1	Tertiary	University and Polytechnics	18/19	1st Year University or Polytech	NCEA Level 4
2			20/21		NCEA Level 5
3			22/23	Bachelors degree	NCEA Level 6
4			23+	Post graduate	NCEA Level 7

NB: In NZ, Universities are not called Colleges but some secondary schools use this term mainly for ‘status’ and ‘marketing’ reasons.

There are a variety of other school types ranging from religious based schools (catering for years 1- 15), area schools (catering for year levels 7-15), middle schools (catering for years 7-9), and composite or area schools, which are essentially rural schools catering for years 7 to 13. A complete directory of all New Zealand schools is available on the Ministry of Education website:

(https://www.educationcounts.govt.nz/data-services/directories)

Other specific types of schools include:

1. **Kura kaupapa Māori** are state schools where the teaching is in the

Māori language (te reo Māori) and is based on Māori culture and values.
2. **Special schools** are state schools that provide education for students with special education needs. **Integrated schools** are schools that used to be private and have now become part of the state system.
3. **Designated character schools** are state schools that teach the New Zealand curriculum but have been allowed to develop their own set of aims, purposes and objectives to reflect their own particular values.
4. **Independent (or private) schools** are governed by their own independent boards but must meet certain standards in order to be registered. Independent schools may be either co-educational or single-sex. They charge fees, but also receive some subsidy funding from the government. Typical annual fees range from NZ$15,000 – NZ$22,000 for NZ citizens and up to NZ$30,000 for overseas full fee-paying students. Of the 89 private schools in NZ, two have over 1,000 students. Most private schools have students from a high socio-economic standing.
5. **Boarding schools.**
6. **The Correspondence School** (TCS) provides distance learning for more than 20,000 students across New Zealand.
7. **Home based** schooling requires Ministry of Education approval.
8. **Partnership/Charter/Kura Hourua** schools, where (controversially), business and community links are encouraged.

The school leaving age is 16 years with compulsory curriculum delivery to the end of year 10. Secondary education (high school) is dominated by the introduction of a national qualification system beginning at year 11 or age 15. Middle schools have not really been developed but, "Intermediate schools" (Years 7 and 8) have survived, albeit precariously. In 2016 there were 115 Intermediate schools and 345 secondary schools. In NZ, a child starting primary school for the first time between July (when the school roll is counted) and 31 December of a school year, and age five to six, is classified as Year 0. The majority of children begin school between 1 January and before the national July roll count and are classed as Year 1. Most children begin school at age five, but the compulsory beginning age is six. Those starting at six are placed in the same class as five-year-old children.

18.2 A Brief History of NZ Qualifications (after Scott, 1994 and Post Primary Teachers Association (PPTA))

1869 -1870 - University of Otago and University of New Zealand established.

1870s - Passing of Education Act (1877) establishes primary education. Compulsory for ages 7 to14.
- Annual exams for standard 4 upwards.
- Rationing of access to secondary school.

1880s - Standard 4 exams a prerequisite for police, army, prison officers and factory workers under 16.
- Entry to public service employment by exam at standard 6.

1890s - 'Inspectors' exams abolished from standards 1, 2, 3 and 4.

1900s - National scholarships for access to secondary school.
- 'Free place' system established for entry to secondary school with [*British*] social hierarchies, values and systems maintained. Mr George Hogben dominates curriculum thinking.
- Different qualifications for different social and employment purposes.

1910s - Education Act of 1914 required all secondary schools to offer free education to all those who passed a 'Proficiency' examination.
- Leaving certificates awarded by examination or accreditation; Intermediate (Y10).
- Lower Leaving (Y11) and Higher Leaving (Y12). Also a matriculation exam at Y11.
- Technical High Schools introduced to produce trades people and resulted in dichotomy of 'vocational trades' versus 'professions'.

1920s - Eight school awards available from standard 6 to Year 12.
- Training College entrance exam introduced in 1929.

1930s - Abolition of senior and junior scholarships to high school.
- Suspension of public service exams.
- Lower leaving certificate abolished and replaced with **school certificate** as a replacement for the matriculation at year 11 (1934).
- Proficiency exam abolished so that primary students could claim a free secondary school place.
- Secondary education 'free' until age 19 but leaving age is 14 years.

1940s - University Entrance (UE) by accreditation and moved to Year 12 (Y12).

- School certificate (SC) status increased by moving to Y12 as an alternative to UE.
- SC accepted as the entry standard into public service.
- The Thomas Report of 1944 replaced matriculation with University Entrance.
- School resistance produced class streaming based on 'IQ'.
- A 'pass' in 'School Certificate' set at 200 marks over five subjects.

1950s - Very little happened? The 'baby boomers' are born.

1960s - Bursary and sixth form certificate introduced.
- Single subject passes for SC.
- Educator Jack Shallcrass calls for abolition of School Certificate.

1970s - Internally assessed subjects introduced (still Norm Referenced).
- Elley and Livingstone call for University Entrance and School Certificate exams to be abolished with initial discussions of 'learning outcomes'.

1980s - Mix of internal and external assessments still norm referenced.
- Inter subject scaling introduced.
- University Entrance abolished in 1985.
- Link between SC marks and year 12 grades removed.
- Picot report and *'Tomorrow's Schools'* set future directions with Board of Trustees replacing Boards of Governors in schools to be inclusive of community skills.
- New Zealand Employers Federation calls for full internal assessment against standards with removal of distinction between 'trades' and 'academic' courses.
- First use of criterion referenced assessment in 1982.
- University Entrance exams becomes sixth Form Certificate until 2003
- Achievement based assessment begins at year 12 with trialing of grade related criteria in 1986.
- The Hawke Report of 1988 leads to the establishment of the National Qualifications Authority (NZQA) and the National Qualifications Framework in (NQF) under Dr Lockwood Smith (National Party Minister of Education).

1990s - NZ Qualifications Authority established in 1990.
- National Qualifications Framework established in 1993.
- Competency based **Unit Standards developed by NZQA** failed at

schools through lack of funding, training, time, narrow assessment criteria, and inadequate understanding and "buy in' by teachers, *but not* in industry, showing strong links between 'New Right' political ideologies and economic climate of the time.
- PPTA moratorium on Unit standards implementation.
- Standards Based Assessment philosophy continue development.
- NCEA level 1 replaces SC after moratorium lifted.
- **Achievement Standards developed by Ministry of Education.**
- Disparities and management issues between Unit Standards and Achievement Standards a continuing problem.
- PPTA imposes a freeze on development on workload issues.
- Student strikes occur when PPTA place ban on extracurricular work.

2000s - NCEA levels 2, 3 and 4 implemented (not without difficulty!) with year 11 students first sitting external and internal exams in 2002.
- Philosophical clash between norm referencing for ranking students against each other and that of assessing individuals against standards.

> - Concerns over moderation of internally assessed standards addressed. Ongoing.
> - Structural changes to record 'failure' if examinations sat and endorsement with success.
> - Certificates are endorsed with Excellence where a student has 50 excellence credits at the level of the NCEA certificate or above. Where a student has a combination of 50 credits of Merit or Excellence at the level of the certificate or above they will be entitled to a Merit endorsement. Ongoing adjustments and alignments of standards to the curriculum to meet changing policies and industry demands.

Prior to the initial introduction of NCEA in 2001, annual national 'subject' examinations at years 11 to 13 were norm referenced (therefore scaled and ranked). Scaling ensured an approximate 50 percent pass/failure rate for each yearly cohort. Success was infamously considered to be achieving an average of 50 percent in five subjects or gaining a total of 200 marks out of 500. Gaining 200 was a significant social and educational landmark in an individual's schooling at age 15 and largely determined future employment and educational directions. University entrance was possible from success at year 12 (called sixth form), but by the late 1960s, the standard entrance qualification to university was success in bursary examinations at year 13 (then called seventh form). Grade distributions at form six (year 12) were for sixth form certificate and university entrance, determined by school certificate results from the previous year 11 to then, form 5. Bursary exams were passed as 'A' or 'B' (gaining different monetary reward) with scholarship at year 13 considered higher status academically than bursary. Scholarship success provided more money than bursary examination success and also the ability to 'skip' the first year of university studies. Prior to sixth and seventh form (up to 1969), the last two years of high school were called 6a (year 12) and 6b (year 13), firmly based on British grammar school models.

Before the 1960s, there was clear demarcation between 'trades' students who went to 'technical' high schools and 'academic' students who were prepared for university and the 'professions'. Indeed, 'professional' high school courses characteristically demanded learning languages such as Latin and French. The break down of this demarcation of 'colonially inherited' values and attitudes towards learning and employment is still in progress but its legacy in today's national assessments is 'ghosted' in the current competency based assessment (CBA) ('trades' oriented) unit standards and Independent Trades Organization (ITO's) unit standards, and the criterion referenced (CRA) achievement standards ('academic'). The political power of competitive 'New Right' social and economic ideologies, through forums such as the Business Round Table in the 1980s, drove change in school governance and eventually established the National Qualifications Framework (NQF) and the nationwide use of CRA and CBA. Impetus for qualifications change was essentially driven by the PPTA and 'shaped' by party politics (Alison, 2007). It should also be noted that NCEA is an assessment system derived from the national curriculum and assesses only selected aspects of the curriculum. Revisions of national assessment standards are aligned to the 2007 national curriculum revisions. International baccalaureate (IB) and Cambridge International examination (CIE) systems have a presence in New Zealand, but remain relatively minor and a choice for largely private and single-sex schools. Charter schools (Partnership schools) controversially (educationally and politically) attempt to provide other options for mostly disadvantaged families and their children.

18.3 NCEA and current university entrance standard

Students are qualified for entrance to a university in New Zealand when they have obtained:

- NCEA level 3.
- Three subjects at Level 3 and made up of 14 credits each in three approved subjects.
- 10 credits at Level 2 or above in literacy and made up of 5 in reading and 5 in writing.
- 10 credits in numeracy at Level 1 or above made up of achievement standards and unit standards (three specific standards required). (http://www.nzqa.govt.nz/qualifications-standards/awards/university-entrance/)

18.4 Briefly About NCEA

NCEA stands for National Certificate in Educational Achievement and is a product of global educational reforms and experiments from the 1980s onwards. It is an internationally recognized qualification. In essence, NCEA is a standards based assessment system (SBA) that evolved from a criterion referenced assessment system (CRA) based on the national curriculum. Assessments are internally set by teachers and externally set. Both are moderated (quality checked) by the NZ Qualifications Authority (NZQA). Philosophically, standards based assessment, is about assessing an individual student's personal academic best. Today, this has somewhat morphed into competitive pass rate targets and credit accruals for schools and students with an emphasis on summative assessment and an increasing use of internally assessed tasks (http://teu.ac.nz/2015/08/farming-tertiary-education/, http://www.ppta.org.nz/resources/publications/cat_view/14-publications/89-research). NCEA attempts to encourage and reward student explanation of phenomena rather than merely recall. Achievement is recorded as: not achieved, achieve, achieve with merit, and achieve with excellence. There are no percentages associated with results and there is an emphasis on explanation and understanding rather than on knowledge.

18.5 Earth Science in the New Zealand Curriculum

Earth Science and Geoscience are synonymous. Geological science is a branch of geoscience. In New Zealand these areas of study are addressed in the *Planet Earth and Beyond* strand of the national Science curriculum as well as aspects of geography, physics, chemistry and biology. Both geoscience and astronomy have struggled for survival. Prior to 1993, the New Zealand curriculum was dominated by the 1968 syllabus and although aspects of geoscience were included, it was not generally taught, mainly due to lack of trained and qualified teachers and resources. The 1993 science curriculum was a landmark in geoscience education as the subject became an 'equal' partner to physics, chemistry and biology. Figure 18.1 shows how the candidate numbers have varied through time to the abolition of geoscience as an externally assessed standard.

It is a requirement that if assessment tasks set by schools are modeled on online exemplars, that they are significantly modified to address authenticity issues. It is important to note that the assessment standards are derived from the curriculum, but in effect the criterion for each standard is what teachers actually teach in the schools. Level 1 geoscience has 4 standards covering aspects of the *Planet Earth and Beyond* strand of the national science curriculum. A description of these standards is provided in Table 18.2. Fuller descriptions of the criteria are available online at: (http://www.nzqa.govt.nz/framework/explore/domain.do?frameworkId=76197). Assessment is delivered by standards based tasks that are both internally (school based) and externally set and assessed. Internal assessment tasks are moderated by NZQA. And undergo regular review to accommodate changing fashions and needs.

18.6 Tracking the Numbers

Although beyond the scope of this article for a full analysis, Figures 18.2 and 18.3 show the 2014 candidate numbers (Data source: NZQA) for the Level 1 geoscience assessment standards and Table 18.2 shows the level 1 geoscience standards, all of which are currently internally set and assessed. Figure 18.1 is a very sad graph as it documents the rise of geoscience at the introduction of NCEA external examination assessments in 2002 to its death as an externally examined subject in 2011. The number of students studying Earth science in NZ remains low, with approximately 3000 at year 11, 1700 at Level 2 and 800 at Level 3. In a country where geological processes are obvious, it is a challenge to increase the numbers of students studying geological processes and composition.

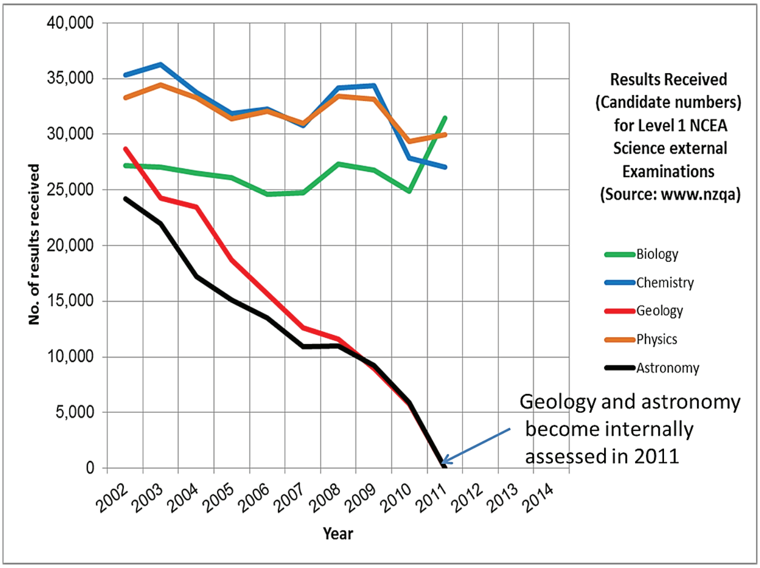

Fig. 18.1 Candidate numbers for Level 1 NCEA (Curriculum level 6. See Table 18.1) since the introduction of high stakes NCEA assessment in 2002. This is the first year of assessment in the geosciences. One can speculate on the reasons for the decline in numbers for Level 1 geoscience. Data for 2013 is not readily available.

(Source: NZQA statistics)

Tab. 18.2 Level 1 Science assessment standards. Note: Investigate means to find information to answer a question using any scientific technique. This usually means Internet searching and primary data gathering. Demonstrate understanding means to show the scientific knowledge and understanding students have learned

Standard	Description
AS 90952 4 Credits	Demonstrate understanding of the formation of surface features in New Zealand
AS 90953 4 Credits	Demonstrate understanding of carbon cycling
AS 90954 4 Credits	Demonstrate understanding of astronomical cycles on planet Earth
AS 90955 4 Credits	Investigate an astronomical or Earth science event

Figure 18.2 shows the number of students attempting the Level 1 NCEA internally assessed geoscience (*Planet Earth and Beyond*) standards for 2014. These standards are described in Table 18.1. It is likely that school science departments will select standards for teaching that they perceive most of their students will achieve. These standards clearly show the lack of geological 'beneath your feet' science options at Level 1. The decline in numbers begs further investigation.

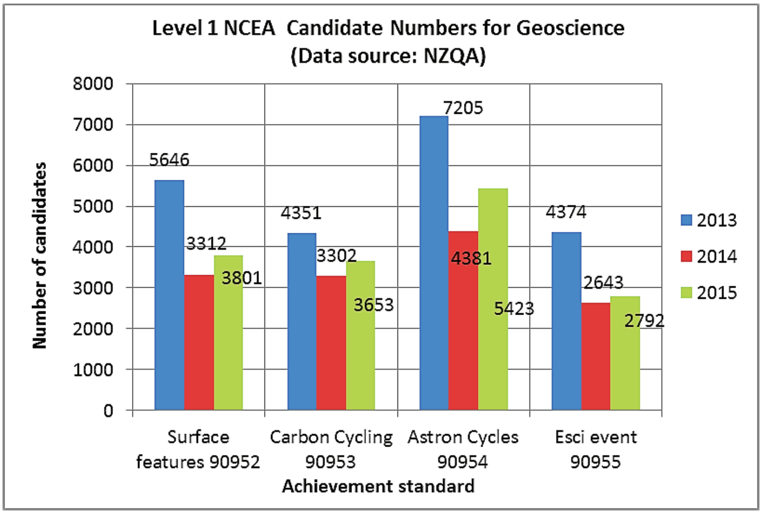

Fig. 18.2 2013, 2014 and 2015 candidate numbers for Level 1 internally assessed geoscience standards.

2011 data is not publicly available. See Table 18.2 for descriptions

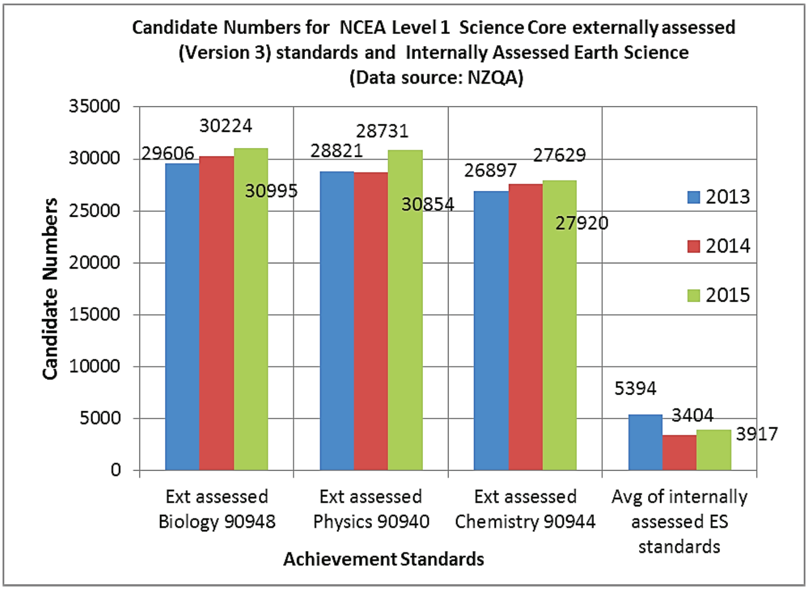

Fig. 18.3 Comparison of candidate numbers for Level 1 externally set science-core standards for physics, chemistry and biology and internally assessed geoscience

It is interesting to compare Figure 18.3 with Figure 18.1. Figure 18.3 indicates that there are around eight times more students who are candidates for physics, chemistry and biology standards than for the geosciences at NCEA Level 1. Earth science candidate numbers remain low with an average of 4,238 after removing externally assessed Earth science and astronomy in 2011. Sustaining the geosciences within a curriculum is clearly a challenge not only globally, but also for NZ educators. Why is this?

18.7 Enter, Earth and Space Science Standards (Geoscience in red)

In 2012, Earth and Space Science superseded Science at NCEA Levels 2 and 3 (last two years of secondary schooling). The examiners' report for 2012 (http://www.nzqa.govt.nz/nqfdocs/ncea-resource/reports/2012/level2/science.pdf) indicated that "Candidates' answers frequently showed insufficient depth for Level 7 of the New Zealand Curriculum in this new subject". Table 18.3 shows a description of standards available at NCEA Levels 2 and 3 (the last two years of secondary schooling).

Tab. 18.3 NCEA Level 2 standards title descriptions

Standard	Description	Style
AS 91187	Carry out a practical Earth and Space Science investigation.	Internal
AS 91188	Examine an Earth and space Science issue and the validity of the information communicated to the public.	Internal
AS 91189	Investigate geological processes in a New Zealand locality	Internal
AS 91190	Investigate how organisms survive in an extreme environment	Internal
AS 91191	Demonstrate understanding of the causes of extreme Earth events in New Zealand	External
AS 91192	Demonstrate understanding of stars and planetary systems	External
AS 91193	Demonstrate understanding of physical principles related to the Earth system	External

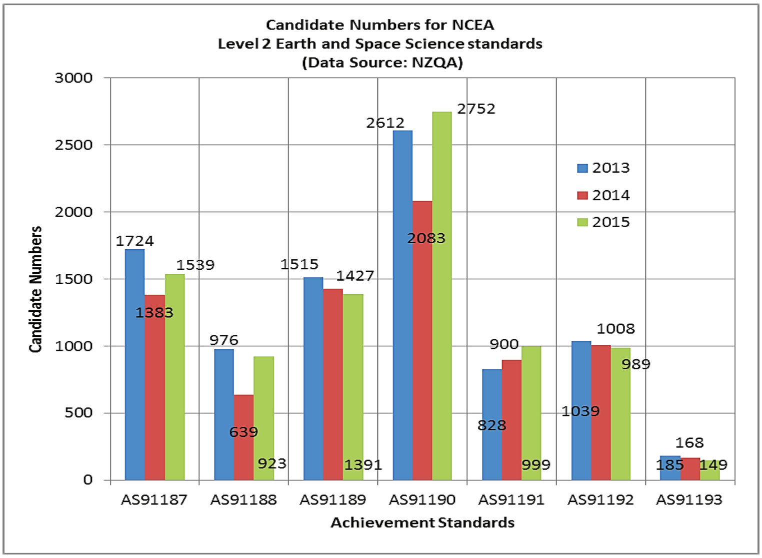

Fig. 18.4 Level 2 NCEA Earth and Space Science standard candidate numbers

Increasing numbers for all geoscience standards is great, but decline for AS91189 is a concern as this is all about understanding geological processes operating locally in a dynamic part of the world (Figure 18.4). Perhaps the word 'organism' in AS91190 triggers a hint of biology and a perception of improved success due to a larger number of teachers who are confident in the biological sciences rather than the geosciences? This graph also illustrates the growth of internal assessment rather than external, except for AS91191 which shows a growth of 17 percent since 2013. This standard is essentially about natural hazards such as earthquakes, landslides and tsunamis.

NCEA Level 3 Assessment Standards

Tab. 18.4 NCEA Level 3 Standard title descriptions

Standard	Description	Style
AS 91410	Carry out an independent practical Earth and Space Science investigation.	Internal
AS 91411	Investigate a socio-scientific issue in an Earth and Space Science context.	Internal
AS 91412	Investigate the evidence related to dating geological events.	Internal
AS 91413	Demonstrate understanding of processes in the ocean system.	External
AS 91414	Demonstrate understanding of processes in the atmosphere system.	External
AS 91415	Investigate an aspect of astronomy.	Internal

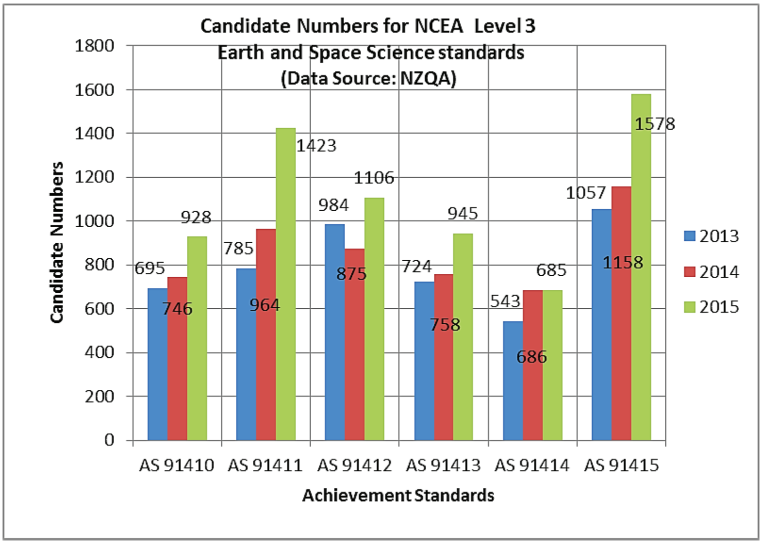

Fig. 18.5 Candidate numbers for NCEA Level 3 assessment standards

For NCEA Level 3, it is interesting that the two standards that attract the most students (91411 and 91415) are not specifically about geoscience, they are about socio-geoscientific issues and astronomy, respectively (Table 18.4). A socio-scientific issue in an Earth and Space context is defined as involving "evaluating the issue and the impact on individuals and society, justifying a personal response to the issue and evaluating a societal response to the issue". Although to achieve this standard it is necessary to significantly connect with the science involved, this standard clearly focuses on the social aspects and is, in effect, environmentalism. (See for example ES3.2B AS91411, http://ncea.tki.org.nz/Resources-for-Internally-Assessed-Achievement-Standards/Science/Earth-and-space-science/Level-3-Earth-and-Space-Science). Both these standards show the most growth with a 44 percent increase from 2013 for AS91411 and a 33 percent increase for AS91415. The introduction of Earth and Space Science (ESS) at Years 12 and 13, as a replacement for Science appears to be successful at attracting more students into geoscience at these levels, despite the fact that the highest number of students are in Astronomy and not geoscience. Astronomy, like geoscience has struggled for its existence in curricula for probably the same reasons as the geosciences. An issue worth further investigation is determining the quality of these students and the reasons for selecting ESS compared with those enrolled in physics, chemistry and biology. Is ESS perceived to be for the lower ability student?

Overall increases in numbers for all standards is great, but this may also reflect the larger numbers that carried on from the 2014 cohort. There are still very low numbers of NZ students who have studied anything about the science of dating geological events (AS 91412). Studying astronomy is arguably Earth/geoscience yet this and socio-geoscience issues attract teacher attention as the most profitable for student credit accrual.

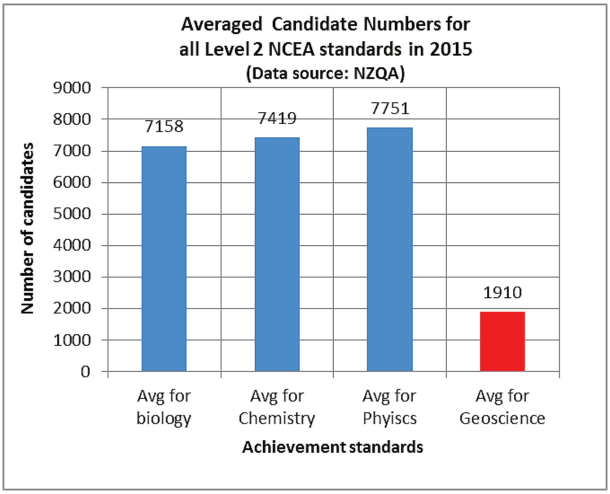

Fig. 18.6 Comparison of averaged candidate numbers for geoscience, biology, chemistry and physics for Level 2, 2015 NCEA results.

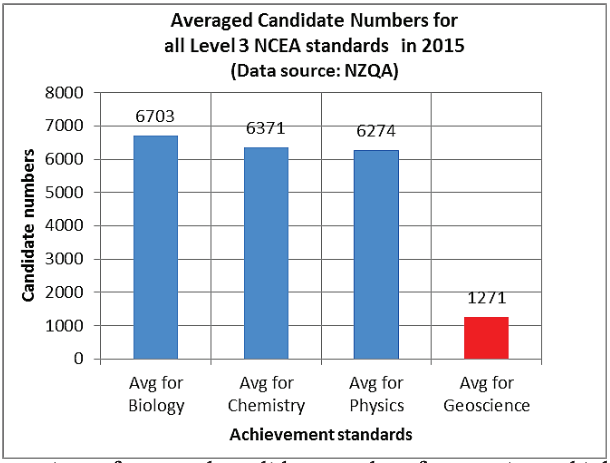

Fig. 18.7 Comparison of averaged candidate numbers for geoscience, biology, chemistry and physics for Level 3, 2015 NCEA results

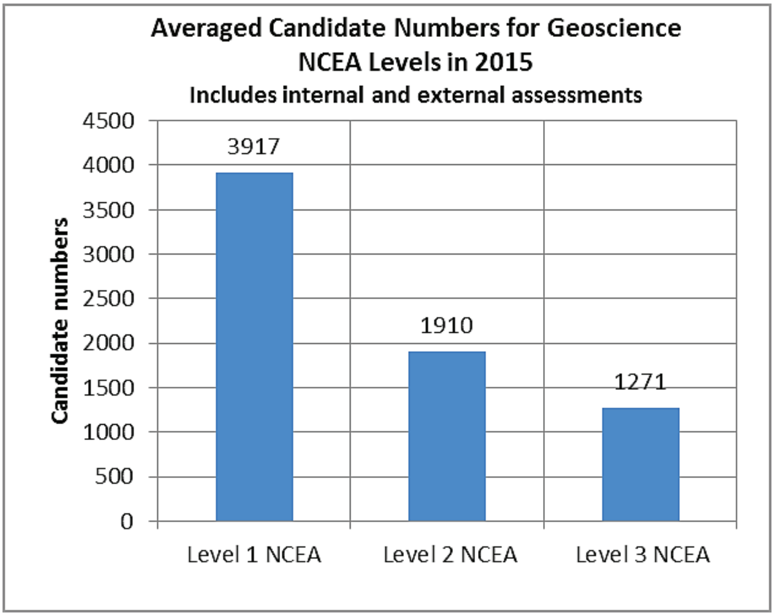

Fig. 18.8 NCEA Level 1, 2 and 3 candidate numbers for geoscience 2015

18.8 Summary

Geoscience (and Astronomy) in the New Zealand curriculum, as represented by the Planet Earth and Beyond strand of the national science curriculum, continue to struggle for survival, but with the introduction of Earth and Space Science standards as a replacement for Science at Years 12 and 13, the geosciences may become more attractive and continue to grow in student quality as well as enrollments. Figure 18.5 is encouraging, but time will tell. A key aspect to this growth is the need to boost the very low numbers engaged in learning the Earth sciences at NCEA Level 1.

This can be achieved by:

1. Developing valid and dynamic formative learning resources.
2. Developing valid and dynamic summative internal assessment tasks.
3. Increasing quality and quantity of professional development courses in geoscience, especially at primary and secondary school level.
4. Encouraging geoscience graduates to enter the teaching profession.
5. Educating politicians in the important values associated with learning geoscience.

NZQA have well-established 'best practice workshop' programs in all aspects of assessment of science standards. Geosciences teaching is well established and of international standard at all NZ universities. It is also clear that there is a need to address the large drop in candidate numbers engaged in physics, chemistry and biology at years 12 and 13 or Sciences overall, where, according to these data (Figures 18.3, 18.6 and 18.7), there are around 4 times fewer students from NCEA Level 1 Sciences (≈30,000) moving on to Level 3 (≈6500). Figure 18.8 shows the candidate numbers for geoscience standards assessment in 2015. Around 4 percent (1271/30,000) of the NCEA Level 1 cohort end up engaged in learning Earth science at NCEA Level 3 in their final year of secondary school. There are 345 secondary schools recorded on the New Zealand Ministry of Education schools directory.

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Glenn Vallender

After 38 years of teaching secondary school biology and science, Glenn retains his passion for geoscience education into semi-retirement. He now manages a small independent educational research company writing customised resources for schools, mentoring students and conducting independent educational projects. Glenn is the editor for the Geoscience Society of NZ Newsletter and is active in all things geoscience. When not doing this, he volunteers a day a week in the archives section of the Ashburton Museum, is a health shuttle bus driver for St John, helps the program team for U3A, tries to play golf and does stage crew for musical theatre. **Qualifications**: BSc (Cant.). Dip. Sci. (Massey). Dip. Tchg. (NZ Govt.) MSc. PhD (Curtin).

Chapter 19

Earth Science Education in Schools: Present Scenario and Future Prospects in Pakistan

Saima Siddiqui, Safdar Ali Shirazi and Wajahat Majeed Khan

Abstract

Twenty-first century challenges lead Earth science to play vital role and enjoy a distinct status among the modern disciplines of the physical and life sciences in developed countries. Unfortunately, Earth science education in Pakistan has not yet grown and developed, causing many problems in progressing this subject. This paper is an effort to outline the current status of this discipline in Pakistan. Various issues related to present state of Earth science education in the country, *e.g.* curriculum development, textbooks, tools of science and technology, trained and qualified teachers, are discussed. Earth science education in Pakistan needs to systematically advance its curriculum at all levels in schools and require modern teaching strategies and institutional infrastructure to develop interest and conceptual understanding of this discipline among students. This will enable Earth science students to address the challenges of the present and meet the needs of the future.

Keywords: Earth science, education, curriculum, future perspective, Pakistan

19.1 Introduction

Discovering natural resources to sustain an increasing population, mitigating natural hazards that affect infrastructure and populations, and achieving the goals for sustainable development are the present tasks that provide Earth science education a decisive role in confronting these daunting challenges. Various sciences are used to study the Earth, however, the four fundamental areas of Earth science study are: astronomy (Science of the Universe), meteorology (Science of the Atmosphere), geology (Science of the Earth), and oceanography (Science of the Oceans). Earth science study involves various sub-disciplines: ***geology***, Earth's materials, structures, processes and changes over time; ***geomorphology***, landforms and features; ***hydrology***, water on the surface and in the ground; ***meteorology***, the atmosphere and its phenomena; ***geophysics***, physical properties of rocks, Earth's interior and surface; ***geochemistry***, rocks chemistry; ***astronomy***, planets and their satellites and related studies.

It is worthwhile emphasizing two important features of Earth science. First, it focuses on the materials and features of rocks on the surface, as well as water and mineral reservoirs at great depths within the Earth, and air masses circulating at great heights above the planet. Thus, the Earth scientist has to have a good three-dimensional perspective (Earth's surface, underground features, and the atmosphere). Second, there is the fourth dimension: time. The Earth scientist is responsible for working out how the Earth evolved over millions of years. For example, what were the physical and chemical conditions operating on the Earth And the Moon 3.5 billion years ago? How has the atmosphere developed? and how did their composition change with time? How did the oceans form, and finally? how did life begin and evolve on the Earth? (Windley, 2016).

U.S. Next Generation Science Standards (NGSS) established a clear status for the subject that Earth science should have equal status with the Life science, Physical Sciences, Engineering and Technology. While The Center for Geoscience Education and public understanding at the American Geosciences Institute has issued an incredible report on Earth science education in middle and high schools, which fail to assign Earth science this status, unfolding in detail substantial gaps between recognized priorities and lagging practice. It details and analyzes key indicators, including the presence of Earth science topics in national standards, consideration of Earth science as a graduation requirement, and recognition of Earth science courses for college admission (American Geoscience Institute, 2013).

The International geoscience Education Organization (IGEO) designed a vibrant program, initiated through launching the International Earth Science Olympiad (IESO); educating future citizens who will perform better as they understand Earth's dynamic processes, and prepare them for tackling the issues involved. Aimed at sustainable development and efficient natural hazard management, IGEO set globally accepted goals, objectives and a syllabus for Earth Science education. Practical exercises, teaching units, geoscience textbooks, Earth learning ideas (ELI) in various languages, and many other activities like Geoscience Conferences are organized to promote Earth science education worldwide.

Fatima et al. (2015) stated the problems with and reasons for treating a bridging subject between the physical and social sciences, like Geography, as a separate entity in Pakistan. For nearly a century prior to the 1947 Indo-Pakistani partition, Geography was taught as a compulsory academic discipline in schools, colleges and universities of the subcontinent. But its status and role were never appraised. The primary and secondary level curriculum placed and taught it within other subjects at each level up to Grade 10. Hence, the subject as a whole remained undeveloped. Recently, the subject was introduced at primary and tertiary levels within a Geography and History textbook. The lack of an integrated curriculum and textbooks, insufficient knowledge and untrained teachers, ignorance of modern techniques and research all brought Geography to a standstill nationally and sapped interest from the subject.

Hogarth (1921), however, contends that dynamic environments create new trends for young pupils, as they want to learn according to modern society's demands to secure their future in rapidly changing employment markets. Unlike other physical and life sciences, the future existence of Earth Science depends on accessing new advanced techniques and ways of engaging learners, demanding a rational response from the education sector. Unwin (1992) and Walford (2001) maintain that Geoscience is an academic discipline with a marked conceptual difference between schools and universities and that changes in the Earth science curriculum in school textbooks must necessarily reflect societal and technological changes. Korthagen (2004) and Gudmundsdottir (1990) stated that subject knowledge and transfer techniques greatly impact future promotion of the subject as "teachers have values, influenced by their subject knowledge that affects how they teach".

As no subject in Pakistan is taught under the title of "Earth science" at school, we evaluate the current status of Earth science education in schools by analyzing relevant content found across the curriculum (*e.g.* social studies, Pakistani studies, and geography curriculum) and textbooks used in Pakistani schools (primary, secondary, tertiary). Furthermore, we analyze teaching and learning activities in geography education at both public and private schools. This paper finally recommends how Earth science education can be promoted in Pakistan.

19.2 Pakistan’s Education System

Pakistan’s education system (Table 19.1) is comprised of public and private institutions. The public institutions are managed and controlled by a public education authority or a government agency, while the private education system is managed and controlled by non-governmental organizations (NGOs), such as business enterprises, religious bodies, or trade unions. The public and private sectors run different education systems. Private institution numbers are increasing drastically due to well managed infrastructure and standard curriculum. Private schools generally conduct both the metric (Pakistan’s national school system) and O levels (the Cambridge internationally recognized qualification). This dual education system and choice of language (English or Urdu) confuse students when selecting appropriate subjects at secondary and higher secondary school. Furthermore, regional disparities in education facilitation and form, and modernized curriculum at each level/grade cause issues.

Tab. 19.1 Framework of Pakistan’s formal and higher education system.

Level		Award type	Class/School Year	Award Example
Tertiary	Higher Education	Doctoral	21^{st}	PhD
			20^{th}	
			19^{th}	
		Masters	18^{th}	M.Phil/MS/MBA, M.Sc (Eng), M.E., M.Arch etc.
			17^{th}	
		Bachelor	16^{th}	BS, B.E., B.Arch., BSc(Eng.), BSc (Agri), MA/ M.Sc (16 year), LLB, B.Com (Hons), MBBA, DVM, PharmD, etc.
			15^{th}	
		Associate Ordinary Bachelor	14^{th}	BA/B.Sc (Pass), ADE, Associate Degrees etc.
			13^{th}	
Higher Secondary	Intermediate	Higher Secondary School Certificate (HSSC)	12^{th}	F.A, F.Sc, ICS, I.Com, DBA, D,Com etc
			11^{th}	
Secondary	Matriculation	Secondary School Certificate (SSC)	10^{th}	Metric
			9^{th}	

Elementary			Middle	8th	Middle certificate
				7th	
				6th	
			Primary	5th	Primary Certificate
				4th	
				3rd,	
				2nd	
				1st	

Source: Adapted from Higher Education Commission, Pakistan (HEC)

Table 2: Earth science syllabus throughout Pakistan's school system.

Level	Institution	Class/ School Year		Earth Science related content (Government Institutions)	Earth Science related content (Private Institutions)
Secondary	Higher Secondary	12th	A level (in Private Schools)	**GEOGRAPHY SYLLABUS PART-II** **World Regional Geography:** 1. A brief Geographical introduction to the World 2. A geography of the continents: Physical features, Climate, Population. 3. Economic Geography of Pakistan, China, Saudi Arabia, Japan, UK, USA, Sudan, Brazil with reference to: Population, Agriculture, Mineral and Energy resources, Industries, Trade **PRACTICAL PART II** Map Projections: Major types and their uses. Representation of statistical data by: Line graph: Bar graph, Pie graph Distribution maps by Dot Method and Shade Method. Topographical Sheets: Marginal Information identification of Natural and Cultural features. **GEOLOGY SYLLABUS** **1. Paleontology** General Introduction to animal kingdom. Brief resume of Invertebrate Paleontology. Classification of Vertebrates up to class level. Brief outline of Jawless Vertebrates, Fishes Amphibians, Reptiles, Birds and Mammals. Sequence of vertebrates through time. Cenozoic fossil vertebrates. **2. Stratigraphy** Introduction to stratigraphy. Principles of Stratigraphy. Standard Time Scale. Significance of terms used in Time Scale. Distribution of Vertebrate fossils in Siwalik Group of Pakistan and its important Vertebrate fossils. Brief description of the Indus Basin. **3. Physiography** Physical features of Pakistan: Geological Structures produced by diastrophism. Nature of Earth Movements: Orogenesis, Epeirogenesis, Folded Mountain, Geosynclines, Mountain building, Faulting: Elements of faults, Simple classification of faults (displacement and slip classifications), Joints and Cleavage: Elementary concepts. **4. Practical** Interpretation of morphology from topographic maps, including profile drawing. Definition of outcrop, dip and strike. Simple completion of outcrop and determination of dip. Drawing of simple geological sections. Determination of the hardness of minerals, determination of specific gravity of minerals and rocks by Walker's and Jolly's balance.	<u>**PHYSICAL GEOGRAPHY**</u> **1. Hydrology and fluvial geomorphology** The drainage basin system, Rainfall – discharge relationships within drainage basins, River channel processes and landforms **2. Atmosphere and weather** Local energy budgets, The global energy budget, Weather processes and phenomena **3. Rocks and weathering** Elementary plate tectonics, Weathering and rocks, Slope processes and development <u>**ADVANCED PHYSICAL GEOGRAPHY**</u> **1. Tropical environments** Tropical climates, Tropical ecosystems, Tropical landforms, Sustainable management of tropical environments **Coastal environments** Wave, marine and sub-aerial processes, Coastal landforms of destructive and constructive coastlines, Coral reefs, Sustainable management of coasts **3. Hazardous environments** Hazardous environments resulting from crustal (tectonic) movement, Hazardous environments resulting from mass movements, Hazard resulting from atmospheric disturbances, Sustainable management in hazardous environments **4. Arid and semi-arid environments** The distribution and climatic characteristics of hot arid and semi-arid environments, Processes producing desert landforms, Soils and vegetation, Sustainable management of arid and semi-arid environments <u>**GEOGRAPHICAL SKILLS**</u> **Graphs** bar graphs, divided bar graphs, line graphs, scatter graphs (including line of best fit), pie charts, proportional circles, triangular graphs, climate graphs, etc. **Photographs** color, black/white, aerial, terrestrial, satellite. **Maps** survey maps (1:25 000 and 1:50 000 scales), flow line, isoline, choropleth, sketch, etc. **Diagrams** two and three dimensional, with/without annotation, flow diagrams, etc. **Written** text from a variety of sources (including newspapers, articles, books, interviews) **Numeric** tables, charts, raw data, etc. **Cartoons**

		11th		**GEOGRAPHY SYLLABUS PART-I** 1. Geography: Definition, Branches, Scope and importance. 2. Physical Geography: Its components: The Earth as a planet, The Earth's shape and size, The Earth's composition & structure, The distribution of Land and Water, Rocks Formation. Classification and Characteristics, Major Landform: Mountains, Plateaus, Plains. 3. Weathering and its types. Physical Features produced by running water, glaciers, wind. 4. Oceans and their movements: Currents. Tides & Waves. Their causes and effects. 5. The Atmosphere: Composition, Weather & climate, Elements of weather & climate: Temperature, Pressure & Winds, Moisture: Humidity & Precipitation. 6. Physical Environment and Man: Physiography and Man, Climate and Man. **PRACTICAL** Location in Geography: Latitudes & Longitudes, Determination of Time. Methods of finding directions. Maps: Types & Uses. Scales: (a) Methods of showing scales: Statement of Scale, Representative Fraction (R.F.), Plane or linear scale is also known as graphic scale, (b) Conversion of scales. (c) Construction of simple scale. Methods of showing relief. Identification and uses of the following: (a) Rocks. (b) Thermometers. (c) Barometer. (d) Rain gauge. **GEOLOGY SYLLABUS** **1. PHYSICAL GEOLOGY** **Rivers and Landscapes** Geological Processes. Weathering and Erosion. Processes of Stream Erosion; Transportation by streams. Competence and Capacity of Streams. Drainage Basin. Valley Growth. Base level; Graded Stream. Cross Profile, Drainage Pattern, Meandering. Cycle of Erosion. Landforms (*e.g.* cuesta, escarpment, dip-slope, mesa). **Groundwater** Porosity and Permeability: Groundwater zones; Movement and Discharge of Groundwater; Erosion and Transportation due to Groundwater; Deposition by Groundwater; Water-logging and Salinity in Pakistan. **2. CRYSTALLOGRAPHY** Elements of symmetry, plane, axis and center of symmetry. Symmetry of normal classes only. An outline study of the six systems of symmetry. **3. MINERALOGY** The common rock-forming minerals; their physical characters, chemical composition and modes of origin and occurrence; quartz, feldspar mica. (Muscovite and biotite), olivine, augite, hornblende, garnet, tourmaline, epidote, chlorite, apatite, zircon, kyanite. Economic minerals, and rocks, their chemical composition, occurrence and uses; diamond, graphite, sulphur, gold, silver, copper, magnetite, haematite, limonite, galena, zincblende, cinnabar, stibnite, chalcopyritc, pyrite, orpiment, argentite, corundum, cassiterite, chrmoite, spinel, rutile, bauxite, pyrolusite psilomelane, magnesite, siderite, aragonite, malachite, apatite, halite, magnganite, rhodocrosite, calcite, dolemite, flourite, barytes, celestite, gypsum. **4. PETROLOGY** What is magma? What are igneous rocks and how they are formed? What are sedimentary rocks? How they are formed? Classification of Sedimentary rocks. What is metamorphism? What are the main types of metamorphism and how the metamorphic rocks are formed? Outline classification of igneous rocks. An outline of their modes of origin and diagnostic characteristics. granite, aplite, pegmatite, granite porphyry, felsite, felsite porphyry, obsidian, pitchstone, perthite, pumice, volcanic ash, tuff, breccia, agglomerate, diorite, quartz diorite, diorite porphyry, basalt porphyry, melaphyre, basalt trap, trap, andesite, gabbro diabase, quartz. gabbro, porphyry, pyroxenite, dunite, hornblendite/peridotite, serpentine. Common sandstone, graywacke, limestone, dolomite, marl, conglomerate, shale, mudstone, siltstone. quartzite, chlorite actinolite schist, biotite schist, garnet mica schist, gneiss, granite gneiss, kyanite, amphibolite, talc schist, serpentinite, hornfels. **PRACTICAL** Interpretation of morphology from topo maps including profile drawing. Definition of outcrop, dip and strike. Simple completion of outcrop and determination of dip. Drawing of simple geological sections. Determination of the hardness of minerals, determination of specific gravity of minerals and rocks by Walker's and Jolly's balance.	
	Secondary	10th 9th	O level (in Private Schools)	Understanding Geography Earth and Its Basic Concerns The Earth Oceans and Seas The Atmosphere Human Geography Population and settlements Environment	Plate Tectonics and Associated Hazards. Landforms and landscape processes, Weathering, River processes, Marine processes. Weather and Climates and Associated Hazards. Ecosystem; change and Challenge. Economic development and the use of resources, Agricultural systems, Industrial systems, Energy and water resources, Environmental risks and benefits: resource conservation and Management. Geographical Investigation and Skills, Map work, Maps, Diagrams, Graphs, Tables of Data, Written Material, Photographic and Pictorial Material (including Field Sketches).

Elementary	Middle	8th	Maps and Diagrams Agents of Landform change Oceans and Seas Natural Disasters Natural Regions Climate of Pakistan Neighboring regions of Pakistan	Maps and Diagrams Agents of Landform change Oceans and Seas Natural Disasters Natural Regions Climate of Pakistan Neighboring regions of Pakistan
		7th	Physical state of Earth (interior, plate tectonics, volcanoes). Denudation (weathering, erosion, mass wasting). Atmosphere (composition, structure, temperature, air pressure, wind circulation and precipitation). Mining and power resources. Geographical aspect for Agriculture, Industry, transportation.	Physical state of Earth (interior, plate tectonics, volcanoes). Denudation (weathering, erosion, mass wasting). Atmosphere (composition, structure, temperature, air pressure, wind circulation and precipitation). Mining and power resources. Geographical aspect for Agriculture, Industry, transportation.
		6th	Earth as planet. Globe, maps and their uses. Earth as a home for Human being. Rocks, Major land features. Land features of Pakistan. World population. Human settlements.	Earth as planet. Globe, maps and their uses. Earth as a home for Human being. Rocks, Major land features. Land features of Pakistan. World population. Human settlements.
	Primary	5th	Physical regions. Climate. Soils. Solar System. Environmental Pollution. Longitudes and Latitudes.	Maps. World climate. Life in the desert. Life in the forest. Life in the polar region. Our country. Water and irrigation. Minerals and Power resources. Pakistan and her neighbors.
		4th	Movement of the Earth. Globe and Maps. Components of Maps. Conventional Signs of Maps. Directions.	The Earth in space. Climate. Our country. The western highlands. River Indus and its Plains. The soil and Agriculture. Forest. Water and its Uses. Power Minerals and industries. Transport.
		3rd	Earth as The Living Planet Sun-Heat and Light Natural Resources Save the Earth	Our Country Pakistan Mountains , Rivers and Dams of Pakistan Climate of Pakistan Our Mineral Wealth Continents and Oceans Features of the Earth The Map Skills
		2nd	Earth Resources Heat and light Water Protection of Earth Resources Natural Environment	The Sun and Stars The Moon The Earth Weather and seasons
		1st	Weather Conditions Seasons	Our Earth Sources of Heat on Planet My Native Land Map of Pakistan

Sources: Board of Intermediate and Secondary Education, Lahore, Punjab textbook board, Cambridge A level and O Level Geography Syllabus and Private schools Geography textbooks.

19.3 Earth Science education in Pakistan

The complex and interwoven relationship between Earth science content within other disciplines makes it difficult to isolate as a distinct subject from level 1 to 12, but its primary topics are integrated in the curriculum (Table 19.2) and textbooks of elementary, secondary and higher secondary schools, with some components from biology, chemistry and physics. Its major topics and some core concepts are included in Pakistan studies, social studies, geography and history. Without a solid foundation for developing Earth science understanding and a systematic approach to studying the subject, it is ambiguous at all levels. The present approach, which incorporates Earth science content into other subjects, adversely effects the teaching standards at higher secondary, graduate and post graduate levels. Unlike government schools, private schools teach most of the Earth science topics in geography. In private institutions teachers use maps, atlases, models and computer-based exercises for geography instruction. Qualified teachers, with discipline specific backgrounds, are responsible for these units, ultimately improving the teaching and learning process.

In government administered public schools, Urdu is the instruction language from level 1 to 10, with no fixed rules adopted for teaching Earth studies. Teachers with relevant qualifications are not considered necessary, mainly because Earth science or Geography is not taught separately before 10th level. Punjab, the most populated province of Pakistan, has instituted Geography as a compulsory subject from 6th to 10th level, but teachers with subject specific degrees are yet not recruited. Usually, teachers of Pakistan studies perform this duty or depute another teacher in their school for that purpose. However, the government has appointed subject specialists for teaching Geography at higher secondary level (11^{th}, 12^{th}). The private sector is further divided into two categories, with some adopting the British Cambridge System (O level) and others the country's school system. Schools with the matriculation system cannot afford specific qualified teachers for Earth Science/Geography studies in their institutions so they do not follow the specialized curriculum. The Cambridge system provides standard education, with instruction in English for Earth science or Geography, and appoints teachers with appropriate specific qualifications at each level.

19.4 Challenges and future suggestions

As discussed above, topics of Earth science are currently taught within various disciplines (Geography, Geology, Geophysics Metrology, Oceanography and Environmental sciences) but none have the capability to perform as a distinct applied subject, which alone can prepare a generation to safeguard natural resources, promote eco-efficiency and enhance public participation while empowering communities to become custodians of the Earth and its environment. There is a need to emphasize the individual status of Earth science education in schools. For this purpose, there is a need to revise courses or introduce Earth science education as a separate, independent discipline at all levels.

Earth science, geography or geology cannot command a place among the front-line subjects as an elective subject at secondary and higher secondary levels in Pakistan. Young people are least interested in selecting these subjects perceived as having limited scope and relevance. Organizing awareness campaigns, seminars and workshops could serve to highlight the importance of Earth science education. Students' interest can be enhanced by organizing science model competitions, quiz competitions, essay contests and Earth Science Olympiads. Society as a whole needs heightened awareness of the growing demand for Earth scientists to sustainably meet future needs.

Furthermore, job provisions for Earth scientists are ensured nationally. Pakistan is one of the top ten countries facing the drastic effects of climate change. Earth Science as a distinct and applied compulsory subject at all levels will prove its worth not only at present but for the future as well. A school subject cannot flourish and advance unless its curriculum is systematically upgraded according to modern research in that field. The potential of a subject to enhance knowledge or awareness of issues is not enough; scientific inquiry based curricula is necessary to prepare students to analyze data and design solutions including comprehensive planning and strategies for the sake of planet Earth.

There is a great need to properly train Earth science teachers through regular refresher courses. Teachers must be encouraged to attract students to learn Earth science by using recently developed Earth science instruction methods. Necessary resources such as computers, maps, GIS/RS software, topographical sheets, etc., must be provided to teachers and students. Study tours and field trips are a critical part of Earth science education, which are unfortunately not incorporated in elementary and secondary schools. Hence, it is suggested to organize necessary field visits to study landforms and landscapes. Special funding should be allocated to geography, geology and Earth science departments to establish or update existing laboratories for GIS/RS, geomorphology, geology, environment and soils and computer based mapping applications.

Two associations, All Pakistan Geographical Association (PGA-1948) and Karachi Geographers Association (1957), are active in the country, but in spite of their long histories, have failed to promote Earth science education nationally and internationally. These organizations could help promote advanced training and research in Earth science, geography and geology in Pakistan. They can highlight current issues like global warming, climatic change, hazard analysis, disaster risk management, environmental impact assessment (EIA), and GIS and remote sensing applications for solving these and other problems. These associations can develop international linkages through projects and interaction with Earth scientists globally. Although Pakistanis are becoming more aware of science and technology advancements and the need for highly competitive and systematic approaches to Earth science education, the country's education standards require much more support in the 21st century.

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Chapter 20

Teaching Earth Sciences in Basic and Secondary Education in Portugal

Jorge Bonito, Margarida Morgado and Dorinda Rebelo

Abstract

This work begins by framing the Portuguese Educational System. In a second moment, characterize the Earth Sciences Teaching throughout the non-higher education. Teaching Earth Sciences in basic and secondary education in Portugal has a long tradition. Currently, Earth Sciences are taught from the earliest years of elementary school through the end of upper secondary education. In the 1st cycle of basic education, the study of Earth Sciences is done in the discipline of Environmental Studies, although it is scarce enough during the four years that comprise this cycle of education. In the 2nd Cycle of Basic Education are taught contents of Earth Sciences in the discipline of Natural Sciences, namely in the 5th grade. The discipline of Natural Sciences, in the 7th grade, is entirely dedicated to Earth Sciences (since 2014-2015 there are curricular goals for this level). In secondary education, in the course of Science and Technology, students can choose, in the specific training, the subject of Biology and Geology (in the 10th and 11th grade) and, in the 12th grade, the Geology. Portugal participated for the first time in the 8th edition of the International Earth Science Olympiad, having since achieved bronze, silver and gold medals.

Keywords: Portuguese Educational System, Earth Sciences Teaching, International Earth Science Olympiad.

20.1 Introduction

Teaching Earth Sciences in basic and secondary education in Portugal has a long tradition, dating back to the early nineteenth century.[1] Until the early 1970s, Earth Sciences teaching were placed in a historical-natural context, with special attention to the descriptive aspects of Crystallography and Mineralogy. In an analysis of student manuals from the Estado Novo period (1947-1974), a study concluded that Earth Sciences teaching were in accordance with the values and educational practices of an authoritarian regime, in which the content was used explicitly as a vehicle for the regime's ideological message.[2]

The military revolution of April 25, 1974 led to the establishment of a democratic political regime with the advent of new ideas and the appropriation of a new vision of education. Currently, Earth Sciences are taught from the earliest years of elementary school through the end of upper secondary education.

This article is structured in three parts: the first concerns the organization of the Portuguese educational system and the disciplines therein; a second, subdivided into sections, dedicated to Earth Sciences teaching throughout primary and secondary education; and the third part, regarding the organization and participation of Portugal in the International Earth Science Olympiad.

20.2 The Portuguese Educational System

20.2.1 Structure of the Educational System

The general framework of the Portuguese Educational System (PES) was created by the Basic Law of the Educational System (BLES).[3] The PES is geographically the entire territory of Portugal, including the Continent and Autonomous Regions, with the Ministry of Education responsible for coordinating education policy.

Public education is non-confessional. The mission of education is to pro-

1. Amador, F. (2008). O ensino da Geologia nas escolas portuguesas, durante o século XIX e primeira metado do século XX: reformas curriculares e manuais escolares. *Terrae Didatica, 3*(1), 4-17. Available in: https://www.ige.unicamp.br/terraedidatica/v3/pdf-v3/TD3-4_17.pdf.
2. Mota, T. S. (2001). *História do Ensino da Geologia em Portugal. Análise dos Manuais do Ensino Liceal no Estado Novo (1947-1974).* Master's Dissertation (not published). Braga, Portugal: Universidade do Minho.
3. Law no. 46/86 of October 14, altered by Laws no. 115/97 of September 19, no. 49/2005 of August 30 and no. 85/2009 of August 27.

mote the development of a democratic and pluralistic spirit, respectful of others and their ideas, open to dialogue and free exchange of opinions, forming citizens capable of critically and creatively judging the social environment in which they are integrated and to engage in its progressive transformation.[4] The PES is therefore a response "to the needs resulting from social reality, contributing to the full and harmonious development of the personality of individuals, encouraging the formation of free, responsible, autonomous and solidarity citizens and valuing the human dimension of work".[5]

The PES includes pre-school education, school education and out-of-school education. School education includes basic, secondary and higher education, integrates special modalities, and includes leisure activities.[6] Compulsory schooling applies to children and young people between the ages of 6 and 18 years.[7]

Basic education is universal and free, continuing for nine years. Free education in basic education covers school fees related to school enrollment, attendance and certification, and students may also use the student manuals and school supplies, as well as transportation, food, and accommodation as needed.[8]

Basic education includes three sequential cycles, the first of four years, the second of two years, and the third of three years, organized in the following terms: *a)* in the first cycle, education is global, under the responsibility of a single teacher, who can be assisted in specialized areas; *b)* in the second cycle, teaching is organized by interdisciplinary areas of basic training and is developed predominantly by an area teacher; *c)* in the third cycle, teaching is organized according to a unified curricular plan, integrating diversified vocational areas, and developed under a teacher by discipline or group of disciplines. The articulation between the cycles follows a progressive sequence, giving each cycle the function of completing, deepening and extending the previous cycle, with the perspective of globally unified basic education.[9]

"The course of secondary education spans three years. Secondary education is organized according to different forms, taking into account the existence of courses predominantly oriented to the active life or to the continuation of studies, all of which contain technical, technological, and

4. No. 4, art. 2.º of BLES.
5. No. 5, art. 2.º of BLES.
6. Art. 4.º of BLSE.
7. Law no. 85/2009 of August 27.
8. Art. 6.º of BLES.
9. Art. 8.º of BLES.

vocational training components, with Portuguese language and culture appropriate to the nature of each course. In secondary education, each teacher is responsible, in principle, for a single discipline”.[10]

20.2.2 Basic Curricular Matrix

The current curricular matrix for the first cycle of basic education applies from 2014. In the first and second years, the following curriculum components are included, with the weekly workload indicated in brackets: a) Portuguese (≥ 7 h); b) Mathematics (≥ 7 h); c) Environment Study (≥ 3 h); and d) Artistic and Physical-Motor Expressions (≥ 3 h). The time of weekly training is between 22.5 h and 25.0 h. In the 3rd and 4th years, English is introduced (≥ 2 h). In addition to the aforementioned components, there is Study Support (≥ 1.5 h), developing study and work habits, aiming primarily to reinforce Portuguese and Mathematics; Curricular Enrichment Activities (between 5 and 7.5 h in the 1st and 2nd years and between 3 and 5.5 h in the 3rd and 4th years) and Moral and Religious Education (1 h), are both optional components. The time for weekly training is between 24.5 and 27.0 h.

Schools have the autonomy11 to organize the school days for the second basic education cycle as they consider most convenient, as long as they respect the weekly hours in the curriculum matrix. Since 2012, the following disciplines coexist in the second cycle, with their total cycle time (divided evenly for each of the two years in the cycle): *a)* Languages and Social Studies (1000 h), including Portuguese, English, History and Geography of Portugal; *b)* Mathematics and Sciences (700 h), including Mathematics and Natural Sciences; *c)* Artistic and Technological Education (540 h), including Visual Education, Technological Education, and Music Education; *d)* Physical Education (270 h); *e)* Moral and Religious Education (90 hours), of optional attendance; *f)* Study Support (400 h); *g)* Complementary Offerings, of compulsory attendance, created by the school according to its available school credit. The total time to complete this cycle is 2,700 hours of training.

The last cycle of basic education, is also organized by discipline, with a total timetable for the third cycle as follows: a) Portuguese (600 hours); b) Foreign Languages (720 h), including English and Foreign Language II;

10. Art. 10.º of BLES.
11. Law-decree no. 75/2008 of April 22, altered by Law-decree no. 224/2009 of September 11 and by Law-decree no. 137/2012 of July 2.

c) Human and Social Sciences (650 h), including History and Geography; d) Mathematics (600 h); e) Physical and Natural Sciences (810 h), including Natural Sciences and Physical Chemistry; f) Expressions and Technologies (850 h), including Visual Education, Information and Communication Technologies, and Physical Education; g) Moral and Religious Education (135 h), optional attendance; h) Supplementary Offerings, of compulsory attendance, created by the school according to its available school credit. The total time to complete this cycle is 4,500 h (7th grade - 1530 h, 8th grade - 1435 h, 9th grade – 1,485 h).

20.2.3 Secondary Education Curricular Matrix

The offerings in secondary education[12] include Science-Humanities Courses, Science-Humanities Continuing Education Courses and Science-Technology Individual Courses.

The Science-Humanities Courses[13] constitute an educational offering aimed at those pursuing higher education (university or polytechnic); intended for students who have completed their basic education (9th grade), and been granted a diploma of completion of secondary education, with National Qualifications Framework qualification level 3. These courses include: Science and Technology Courses, Socioeconomic Sciences Course, Languages and Humanities Course, and Visual Arts Course.

The matrix of these courses includes general and specific training components. The first component includes the following disciplines / total hours: Portuguese (560 h); Foreign Language (300 h); Philosophy (300 h); and Physical Education (450 h). In the specific training component there are triennials disciplines (770 h), biennials (a choice of two disciplines, 270 or 315 h), and annuals (a choice of two disciplines, 150 h); with the possibility of another annual discipline, depending on the school's educational project, with a set of subjects common to all courses (150 h). Moral and Religious Education is optional (270 hours).

The Science and Technology Course is framed in the matrix presented in the Science-Humanities Courses. The following offering is found in the general training component: Portuguese (10th, 11th and 12th grade); Foreign

12. Law-decree no. 139/2012 of July 5, altered by Law-decree no. 91/2013 of July 10 and by Law-decree no. 176/2014 of December 12.
13. Law-decree no. 139/2012 of July 5, altered by Law-decree no. 91/2013 of July 10 and by Law-decree no. 176/2014 of December 12 and by Ordinance no. 243/2012 of August 10, rectified by Declaration of Rectification no. 51/2012 of September 21.

Language I, II or III - German, Spanish, French or English (10^{th} and 11^{th} grade); Philosophy (10^{th} and 11^{th} grade); and Physical Education (10^{th}, 11th and 12^{th} grade). The specific training component includes: Mathematics A (mandatory triennial - 10^{th}, 11^{th} and 12^{th} grade); Biennials (10^{th} and 11^{th} grade), in which the student chooses two of the following disciplines: Biology and Geology (10^{th} and 11^{th} grade); Physics and Chemistry A (10^{th} and 11^{th} grade); or Descriptive Geometry A (10^{th} and 11^{th} grade). In 12^{th} grade, the student chooses two annual disciplines, at least one of which is compulsory, from Biology, Physics, Geology and Chemistry, with another dependent on the school's educational project (Anthropology, Computer Applications B, Political Science, Classics of Literature, Law, Economics C, Philosophy A, Geography C, Greek, Foreign Language I, II or III, Psychology B).

The Science-Humanities Continuing Education Courses constitutes a "second educational opportunity for those who did not enjoy it in their own age or who did not complete it and for those who seek it for reasons of cultural and professional promotion", for which students obtain a grade and diploma award or certificate equivalent to those conferred by daytime teaching.[14] The Science-Humanities Continuing Education Courses are composed of the same four courses previously mentioned. Earth Sciences are taught in Biology and Geology (10^{th} and 11^{th} grade) and Geology (12^{th} grade). Since these courses are part of adult education, they are omitted from the section devoted to secondary education.

The individual courses have a long tradition in the Portuguese educational system, as a pedagogical experience of private and cooperative teaching establishments framed in 1967.[15] With the 2012 curricular revision,[16] the individual course plans stay abreast of the remaining training components of secondary education. These courses are, for the most part, dual certificates with a solid scientific and technological component. The courses of the scientific track also have a technological training component. They seek to respond to public expectations on schools, by providing transparency to the business community, the scientific community, local authorities, various institutions, and families, effectively involving the community and its various educational agents at local and regional levels in students' success. Three training components (general, scientific, and technological) coexist in the Science-Technology Individual Course. The programs of the subjects of the general training component and of the scientific training

14. URL: http://www.dge.mec.pt/modalidade-de-ensino-recorrente-sec.
15. Law-decree no. 47.587 of 1967, March 10, 1967.
16. Law-decree no. 139/2012 of July 5.

component of the Scientific-Technological Courses are the Programs of the Scientific-Humanistic Courses, according to the area of knowledge,[17] with the same instruction hours, including for Earth Science.

20.3 Earth Sciences in the 1st Cycle of Basic Education

In the first cycle of basic education, Environment Studies is an area in which concepts and methods from various disciplines, such as History, Geography, Natural Sciences, Ethnography, and others, compete to contribute to students' progressive understanding of the interrelationships between Nature and Society. Environmental Studies is also an area that can promote interaction between all areas of the curricular matrix, constituting as motive and motor for learning in other areas. Earth Sciences is included within Environmental Studies, however, it is rather scarce during the four years comprising this education cycle. Table 20.1 summarizes the Environmental Studies content that integrates Earth Sciences themes, extracted from the Curricular Organization and Programs document on the first cycle of basic education.[18]

17. URL: http://www.dge.mec.pt/cursos-cientifico-tecnologicos-planos-proprios-cct-pp.
18. Ministério da Educação (s.d.). *Organização Curricular e Programas. 1.º Ciclo do Ensino Básico. Estudo do Meio* (4.ª ed.) Lisbon, Portugal: Ministério da Educação. Available in: http://www.dge.mec.pt/sites/default/files/Basico/Metas/Estudo_Meio/eb_em_programa_1c.pdf.

Table 20.1 Subjects of Earth Sciences in Environmental Studies discipline in the 1.st Cycle of Basic Education

Specific content/objectives which integrate Earth Science themes in each year of schooling		
1st grade	3rd grade	4th grade
Topic 3 - Discovering the natural environment ***2. The physical aspects of the local environment*** • Recognize different ways in which water is found in nature (rivers, streams, wells, etc.) ***3. Identify Nature's colors, sounds and smells*** (..., soil, sea, watercourses, ...)	**Topic 3 - Discovering the natural environment** ***2. The physical aspects of the local environment*** • Collect samples of different types of soil: - identify some of its characteristics (color, texture, smell, permeability); - search for what is found on the ground (animals, stones, remains of living beings). • Collect samples of existing rocks in the immediate environment: - identify some of its characteristics (color, texture, hardness ...); - recognize the usefulness of some rocks. • Distinguish forms of relief existing in the region (elevations, valleys, plains ...): - observe directly and indirectly (photographs, illustrations ...); - locate on maps. ***3. The stars*** • *Distinguish stars from planets (sun - star, moon - planet).* **Topic 6 - Discovering the interrelationships between Nature and Society** ****5. Mineral exploration of the local environment*** • Survey of mineral exploration sites (mine, quarries, sands ...). • Survey the main mineral products in the region. • Recognize mineral exploration as a source of raw materials (construction, industry ...). • Identify certain hazards to man and the environment arising from mineral exploitation (quarry pollution, silicosis of miners,...).	Topic 1 - Discovering yourself ***2. The safety of your body*** *Knowing anti-seismic safety rules* (prevention and behaviors to have during and after an earthquake). **Topic 3 - Discovering the natural environment** ***1. Physical aspects of the environment*** • Recognize and observe phenomena of: condensation (clouds, fog, dew); solidification (snow, hail, frost); precipitation (rain, snow, hail). • Conduct experiments that represent phenomena of: evaporation; condensation; solidification; precipitation. • Understand that rainwater infiltrates the soil giving rise to water sheets. • Recognize springs and water courses. ***3. The stars*** • See the shape of the Earth through photographs, illustrations ... • Observe and represent aspects of the Moon in the various phases. • Observe the solar system on a model. **Topic 4 - The discovery of interrelations between spaces** ***1. The contact between land and sea*** • Directly or indirectly observe some aspects of the coast (beaches, cliffs, dunes, cables,...) and the Portuguese coast ("Ria" of Aveiro, Cabo Carvoeiro, Cabo da Roca, Estuary of Tagus and Sado, Ponta de Sagres). • Find on the map of Portugal. • Find on maps islands and archipelagos (Azores and Madeira). • Find the continents and the oceans on the planisphere and globe. • Recognize the Atlantic Ocean as the maritime border of Portugal. * • Observe the action of the sea on the coast. * • Watch the tides. **Topic 6 - Discovering the interrelationships between Nature and Society** ***2. The quality of the environment*** • The quality of the surrounding environment: - identify and observe some factors that contribute to the degradation of the nearby environment (dumps, polluting industries, destruction of historical heritage,...); - list possible solutions; - identify and participate in ways of promoting the environment. • Air quality: - recognize the effects of air pollution (greenhouse effect, ozone depletion, acid rain,...); • Water quality: - recognize some forms of pollution of watercourses and oceans (sewers, industrial fluids, black tides,...). • Identify some environmental imbalances caused by human activity: - extinction of resources.

General objectives
2 - Identify basic elements of the surrounding physical environment (relief, rivers, fauna, flora, weather, etc.).
6 - Use some simple processes to understand the surroundings (observe, describe, formulate questions and problems, advance possible answers, rehearse, verify), assuming an attitude of permanent research and experimentation.
7 - Select different sources of information (oral, written, observation, etc.) and use various forms of simple data collection and processing (interviews, surveys, posters, graphs, tables).
8 - Use different modalities to communicate the information collected.

Note: There is no Earth Science content in the 2nd grade of the first cycle of basic education. Program points that are marked with an asterisk (*) are only incorporated when locally relevant.

20.4 Earth Sciences in the Second Cycle of Basic Education

Earth Sciences content is taught within Natural Sciences, specifically in 5th grade. In the academic year 2014-'15 curricular goals become inforced, including learning objectives and descriptors for each component. Each descriptor is written in direct, objective and concise language, for the teacher who must select the most appropriate teaching strategies to achieve the educational goals, including adaptating the language to different schooling levels. Table 20.2 presents the approved curricular goals and proposed Earth Sciences content, with associated academic hours.

Table 20.2 Subjects of Earth Sciences in Natural Sciences discipline in the 2.nd Cycle of Basic Education

Domain: Water, air, rocks and soil - terrestrial materials *Subdomain: Importance of rocks and soil in the maintenance of life*	
Content	**Goals**
1. Soil 1.1. Factors that condition the formation and evolution of a soil 1.2. Soil composition - profile 1.3. Soil types - porosity and permeability 1.4. Soil and agriculture 1.5. Soil conservation 2. Rocks 2.1. Mineral and rock concepts - basic properties 2.2. Main groups of rocks 2.3. Minerals of major rock groups 2.4. Geographical distribution of rocks in Portugal 2.5. Current use of rocks and minerals	*1. Understand that soil is a life support material (360 min)* 1.1. Define soil. 1.2. Indicate three functions of the soil. 1.3. Identify soil components and properties, based on practical laboratory activities. 1.5. To describe the role of biological agents and atmospheric agents in soil genesis. 1.7. Relate soil conservation to agricultural sustainability. 1.8. Associate some methods and instruments used in agriculture with scientific and technological advances. *2. Understanding the importance of rocks and minerals (315 min)* 2.1. Define rocks and minerals. 2.2. Distinguish different groups of rocks, based on some properties, using simple dichotomous keys. 2.3. Recognize the existence of minerals within rocks, based on observations of hand samples. 2.4. Refer applications of rocks and minerals to various human activities, based on a practical field activity local to the school.

Subdomain: The importance of water to living things	
Content	**Goals**
3. Water 3.1. Water and life 3.1.1. Water circulation in nature - hydrological cycle 3.1.2. Distribution of water on the planet - reservoirs, streams and groundwater 3.1.3. Functions of water in living beings 3.1.4. Water and Health 3.2. Water and human activity 3.2.1. Water quality - drinkable and non-potable 3.2.2. Water consumption - The situation in Portugal - Savings measures 3.2.3. Water pollution - biological, chemical and physical contamination 3.2.4. Water treatment - Water Treatment Station: decantation, filtration, boiling, chemical disinfection and distillation - Wastewater Treatment Station: Wastewater treatment	*4. Understanding the importance of water for living beings (225 min)* 4.1. Represent the distribution of water on the planet (reservoirs and flows), using the hydrological cycle. 4.2. Refer to the availability of fresh water (surface and underground) on the Earth, from information on the total volume of water available. 4.3. Identify water properties, based on practical laboratory activities. 4.4. Present examples that show the existence of water in all living beings, through the consultation of diversified documents. 4.5. Describe two functions of water in living beings. 4.6. Explain the importance of water composition to the health of human beings, from reading labels 4.7. Refer the role of fluoride in oral health. *5. Understanding the importance of water quality for human activity (270 min)* 5.1. Classify the types of water for consumption (drinking water and mineral water) and types of water unfit for consumption (brackish water and polluted water). 5.2. Describe the evolution of water consumption in Portugal, based on information expressed in graphs or tables. 5.3. Propose measures that aim to guarantee the sustainability of the water for consumption. 5.4. Indicate three sources of pollution and water contamination. 5.5. Explain the consequences of pollution and water contamination. 5.6. Distinguish the function of the Water Treatment Station from the function of the Wastewater Treatment Station.

20.5 Earth Sciences in the Third Cycle of Basic Education

The 7th grade Natural Sciences discipline is entirely dedicated to Earth Sciences. The curricular goals, which came into play in the 2014-'15 academic year, apply to 12 concepts as outlined in Table 20.3[19].

19. The curricular goals and the Natural Sciences Program of the 3rd cycle of basic education are available in: http://dge.mec.pt/metascurriculares/index.php?s=directorio&pid=22.

Table 20.3 Subjects of Earth Sciences in Natural Sciences discipline in the 2.nd Cycle of Basic Education

Domain: Earth in transformation Subdomain: External dynamics of the Earth	
Content	Goals
1. Geological landscapes 1.1. Magmatic Landscapes - Main features of volcanic landscapes - Main features of plutonic landscapes 1.2. Metamorphic Landscapes - Main features of metamorphic landscapes 1.3. Sedimentary Landscapes - Main characteristics of sedimentary landscapes - Genesis, classification and identification of sedimentary rocks	1. Understanding the diversity of geological landscapes (657 min) 1.1. To identify landscapes of volcanic rocks and landscapes of plutonic rocks through their main characteristics. 1.2. Give two examples of landscapes of magmatic rocks in Portuguese territory. 1.3. Relate the main characteristics of landscapes of metamorphic rocks. 1.4. Indicate two examples of landscapes of metamorphic rocks in national territory. 1.5. Describe the main features of sedimentary rock landscapes. 1.6. To present two examples of sedimentary landscapes in Portugal. 1.7. Identify the type of landscape in the region where the school is located *2. Understand minerals as basic components of rocks* 2.1. State the concept of mineral. 2.2. Identify minerals in rocks (biotite, calcite, staurolite, feldspar, moscovite, olivine, quartz), correlating some properties with the use of tables. 3. To analyze the concepts and processes related to the formation of sedimentary rocks 3.1. Summarize the action of water, wind and living beings as external geological agents. 3.2. Predict the type of movement and deposition of materials along a watercourse, based on a practical laboratory activity. 3.3. Explain the stages of formation of most sedimentary rocks. 3.4. To propose a classification of sedimentary rocks, based on a practical activity. 3.5. Identify the main types of detrital rocks (sandstone, argillite, conglomerate, marl), chemogenic (limestone, gypsum, rock salt) and biogenic (coals, limestone) based on practical activities. 3.6. To associate some characteristics of the sand to different types of environments, based on a practical laboratory activity.

Subdomain: Internal Dynamics of the Earth	
Content	Goals
2. Drift of continents and plate tectonics 2.1. Theory of continental drift 2.2. Theory of the expansion of the ocean floor 2.3. Plate Tectonics Theory 3. Deformation of rocks 3.1. The behavior of rocks when subjected to stress 3.2. Faults and fractures 3.3. Folds and Rides	4. Understand the fundamentals of the structure and dynamics of the Earth (270 min) 4.1. Present arguments that supported and weakened the Continental Drift Theory. 4.2. Recognize the contribution of science, technology and society to the knowledge of ocean floor expansion. 4.3. Lay out the morphology of the ocean floor. 4.4. Explain the classic (oceanic and continental) evidence that supports the Plate Tectonics Theory. 4.5. Relate the continuous expansion and destruction of the ocean floor with the constancy of the volume of the Earth. 4.6. Solve an exercise that relates the distance to the axis of the Atlantic ridge with the age and paleomagnetism of the rocks of the respective ocean floor. 4.7. Identify the contributions of some scientists associated to the Continental Drift Theory and Plate Tectonics Theory. 4.8. Characterize tectonic plate and the different types of existing limits. 4.9. Infer the importance of convection currents as the “motor” of the mobility of tectonic plates. 5. Apply concepts related to rock deformation (270 min) 5.1. Distinguish fragile behavior from ductile behavior, in diverse materials, based on a practical laboratory activity. 5.2. Explain the formation of folds and faults, based on a practical laboratory activity. 5.3. Relate the observed motion to a fault with the type of applied forces that gave rise to it. 5.4. Identify, in diagrams and images, deformations observed in the existing rocks in the landscape. 5.5. Relate rock deformation to the formation of mountain ranges.

Subdomain: Consequences of the Earth's internal dynamics	
Content	Goals
4. Magmatism and Magmatic Rocks 4.1. Volcanism and volcanic activity - Volcanoes and types of volcanic activity - main types of magmas - Manifestations of secondary volcanism - Distribution of volcanoes on Earth and plate tectonics - Volcanic risks: prediction and protection of property and people 4.2. Genesis, classification and identification of magmatic rocks (volcanic and plutonic) - granite, rhyolite, gabbro, basalt 5. Genesis of metamorphic rocks 5.1. Factors, intensity and types of metamorphism 5.2. Metamorphism and internal dynamics of the Earth 5.3. Classification and identification of metamorphic rocks 6. Rock Cycle 7. Main lithological formations in Portugal 8. Seismic activity 8.1. Origin and registration of seismic waves 8.2. Distribution of earthquakes on Earth and plate tectonics 8.3. Seismic risks - prediction and protection of property and people 9. Contribution of science and technology to the study of Earth's internal structure 9.1 Direct methods: mines and survey 9.2 Indirect methods: earthquakes and meteorites 9.3 Models of the Earth's internal structure - Geophysical model - Geochemical model	6. Understand volcanic activity as a manifestation of the Earth's internal dynamics (405 min) 6.1. Lay out the structure of a volcanic apparatus. 6.2. Distinguish different materials expelled by volcanoes, based on hand samples. 6.3. Establish a relationship between the different types of magmas and the various types of volcanic activity, through a practical activity. 6.4. Exemplify manifestations of secondary volcanism. 6.5. Explain the benefits of volcanism (primary and secondary) to populations. 6.6. Refer measures for prevention and protection of property and people of volcanic risk. 6.7. Infer the importance of science and technology in predicting volcanic eruptions. 6.8. Recognize the volcanic manifestations as a consequence of the internal dynamics of the Earth. 7. Interpret the formation of magmatic rocks 7.1. Explain the genesis of plutonic and volcanic magmatic rocks. 7.2. Identify different types of plutonic rocks (gabbro and granite) and volcanic rocks (basalt and rhyolite), based on hand samples. 7.3. Relate the genesis of magmatic rocks to their texture, based on the size and macroscopic identification of their constituent minerals. 8. Understand metamorphism as a consequence of the Earth's internal dynamics (135 min) 8.1. Explain the concept of metamorphism, associated with the internal dynamics of the Earth. 8.2. List the main factors that cause the formation of metamorphic rocks. 8.3. Distinguish contact metamorphism from regional metamorphism, based on the interpretation of images or graphics. 8.4. Identify different types of metamorphic rocks (schist and other rocks with well defined foliated or banded texture, marbles, quartzites, with a granoblastic texture), using a practical activity. 8.5. Relate the type of structure that the rock presents with the type of metamorphism that gave rise to it, in hand samples. 9. Know the rock cycle (45 min) 9.1. Describe the rock cycle. 9.2. State the geological processes involved in the rock cycle. 10. Understand that lithological formations in Portugal should be explored in a sustainable way (90 min) 10.1. Identify the different groups of rocks in Portugal, using geological charts. 10.2. Refer applications of rocks in society.

	10.3. Recognize the rocks used in some buildings, in the region where the school is located. 10.4. Understand that the exploitation of lithological resources must be done in a sustainable way. 11. Understand seismic activity as a consequence of Earth's internal dynamics (405 min) 11.1. Explain the formation of an earthquake, associated with the internal dynamics of the Earth. 11.2. Associate the vibration of the rocks with the recording of the seismic waves. 11.3. Distinguish the Richter Scale from the European Macrossismic Scale. 11.4. Explain seismic intensity, based on documents of recorded earthquakes. 11.5. Interpret isoseismal lines, in a national context. 11.6. Identify the seismic risk of Portugal and the region where the school is located. 11.7. Characterize some historical seismic episodes of the national territory, based on guided research. 11.8. Indicate the risks associated with earthquake occurrence. 11.9. Describe measures to protect property and people, before, during and after an earthquake occurs. 11.10. Recognize the importance of science and technology in seismic forecasting. 11.11. Relate the distribution of earthquakes and volcanoes on Earth with the different tectonic plate boundaries. 12. Understand the internal structure of the Earth (405 min) 12.1. Relate the inaccessibility of Earth's interior with the limitations of direct observation methods. 12.2. List various technological tools that facilitate understanding Earth's internal structure. 12.3. Explain the contributions of planetology, seismology and volcanology to the knowledge of Earth's interior. 12.4. Characterize, from schematics, Earth's internal structure, based on physical and chemical properties (geochemical and geophysical models).

Subdomain: The Earth tells its story	
Content	Goals
10. Big steps in Earth's history 10.1. Historical time and geological time 10.2. Times in geology - relative and absolute 10.3. Geological time scale - stratigraphic table 10.3. Geological time and sustainability of life 11. Fossils and Their Importance for Reconstructing Earth's History 11.1. Fossils and paleontology 11.2. Processes 11.3. Interpretation 11.4. Flora and fauna as memory	13. Understand the importance of fossils for the reconstruction of Earth's history (405 min) 13.1. Define paleontology. 13.2. Define fossils. 13.3. Explain the various processes of fossilization, using practical activities. 13.4. Relate fossil formation with the physical, chemical and biological conditions of their environments. 13.5. Order events related to fossilization processes, according to the sequence in which they occurred in Nature. 13.6. Characterize large groups of fossils, based on images and hand samples. 13.7. Explain the contributions of fossil studies to reconstructing the history of life on Earth. *14. Understanding the major stages of Earth's history (405 min)* 14.1. Systemize information, in different formats, on the concept of time. 14.2. Distinguish historical time from geological time, based on diversified documents. 14.3. Explain the concept of relative dating, based on geological principles and reasoning, using a practical laboratory activity. 14.4. Distinguish relative dating from radiometric dating. 14.5. Locate Geological Eras in a Chronostratigraphic Table. 14.6. Locate the appearance and extinction of major groups of animals and plants in the Chronostratigraphic Table. 14.7. Infer the consequences of the cyclical changes of terrestrial subsystems (atmosphere, biosphere, geosphere, hydrosphere) throughout Earth's history, based on diversified documents. 14.8. Characterize past geological environments through a practical field activity.

Subdomain: Geological science and sustainability of life on Earth	
Content	Goals
12. Geological knowledge and sustainability of life on Earth 12.1. Human interventions in geological and biological processes 12.2. Impact of external geological systems and their consequences for the sustainability of life 12.3. Impact of scientific and technological developments on society 12.4. Answers to environmental geology problems	*15. Understanding the contribution of geological knowledge to the sustainability of life on Earth (270 min)* 15.1. Associate human interventions with impacts of geological processes (atmosphere, hydrosphere and lithosphere). 15.2. Relate the geological environment with human health and occurrence of diseases in people, animals and plants living in the same environment. 15.3. Extrapolate the effect of population growth on resource consumption, the environment and the sustainability of life on Earth. 15.4. Refer three types of responses (technological, socioeconomic and educational) to environmental geology problems. 15.5. Explain how the relationships between geology, technology and society can contribute to forming a sustainable culture of life on Earth.

The curricular goals clearly identify: the fundamental content that must be taught; the sequential or hierarchical ordering of content throughout various stages of schooling; the knowledge and skills to be acquired and developed by students; and the expected student performance standards / levels that measure achievement of the objectives.

So that teachers do not neglect incorporating practical activities (field and laboratory) in teaching Earth Sciences, some descriptors were defined to impose active learning conditions. Thus, for example:

5th grade

3. Identify the soil components and properties, based on <u>practical laboratory activities</u>.

7th grade

3.5. Identify the main types of detrital rocks (sandstone, argillite, conglomerate, marl rock), chemogenic (limestone, gypsum, rock salt) and biogenic (coals, limestone) <u>based on practical activities</u>.

3.6. To associate some characteristics of the sand to different types of environments, <u>based on a practical laboratory activity</u>.

11.7. Characterize some seismic episodes of the history of the national territory, <u>based on research findings</u>.

20.6 Earth Sciences in Secondary Education

Students in the Science and Technology Course can choose Biology and Geology for their specific training in the 10th and 11th grades, and the frequency of Geology in 12th grade.

In Biology and Geology, the Earth Sciences component assumes the same importance as Biology, with an equal and compulsory workload assigned to each component in the two years of schooling. Figure 20.1 presents the topics covered in secondary education and their respective teaching hours (ST = 45 minutes) (Figure 20.1).

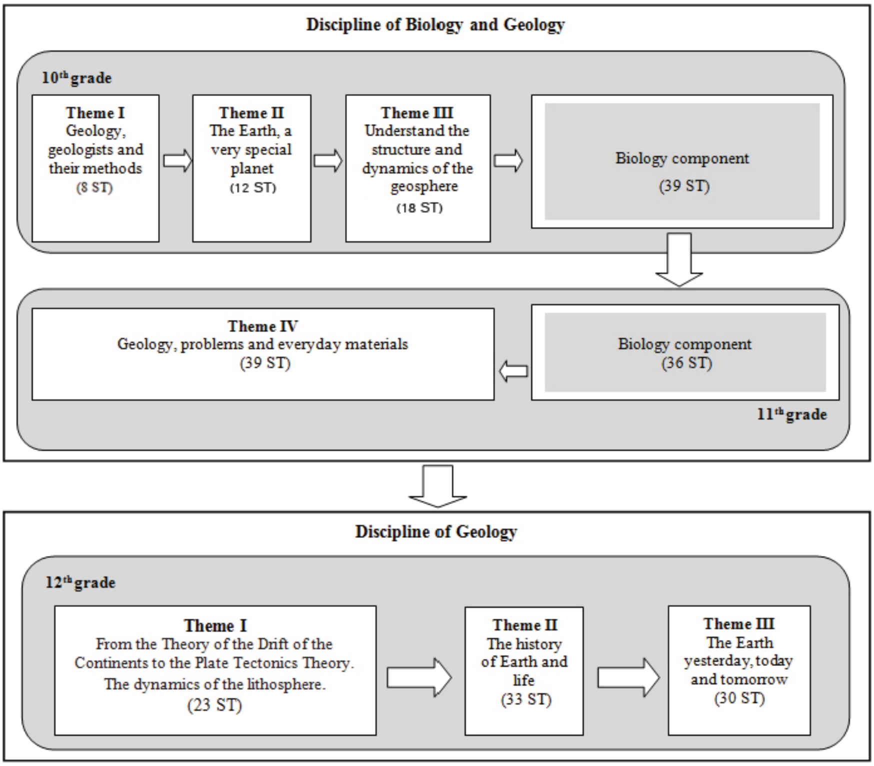

Figure 20.1 – Disciplines and themes of Earth Sciences in secondary education.

The contents of explored Earth Sciences are quite diverse. Content that has already been addressed in basic education (eg: rocks, volcanology, seismology) has been taken up and deepened and more complex content has been introduced and requires a greater degree of abstraction (eg, equivalence between chronostratigraphic and geochronological units) as shown in the following Table 20.4.

Table 20.4 Disciplines and themes of Earth Sciences in secondary education

Discipline of biology and geology		**Discipline of Geology**
10th grade	11th grade	12th grade
(Presentation of a problem / situation) **Theme I -** Geology, geologists and their methods The Earth and interaction between its sub-systems. Rocks, files that tell Earth's history Measuring time and the age of the Earth. Earth, a planet in change. (Presentation of a problem / situation) **Theme II -** The Earth, a very special planet Formation of the Solar System. The Earth and terrestrial planets. The Earth, a planet only to protect. (Presentation of a problem / situation) **Theme III** – Understand the structure and dynamics of the geosphere Methods of studying the geosphere. Volcanology. Seismology. Internal structure of the geosphere.	(Presentation of a problem / situation) **Theme IV** – Geology, problems and everyday materials Human occupation and land use issues. Important processes and geological materials in terrestrial environments. Sustained exploitation of geological resources.	(Presentation of a problem / situation) **Theme I** - From the Theory of Continental Drift to Plate Tectonic Theory. Lithospheric dynamics. Genesis and evolution of the theory of drifting continents. Lithospheric dynamics and major geological structures. (Presentation of a problem / situation) **Theme II** - The history of Earth and life Measuring time and the history of the Earth. Examples of dating methods. Chronostratigraphic table. Correlation of chronostratigraphical and geochronological units. Geo-history. Life in the Precambrian, Paleozoic, Mesozoic, and Cenozoic. Paleogeographical evolution. The geological history of a region. (Presentation of a problem / situation) **Theme III** - The Earth yesterday, today and tomorrow The Earth before the appearance of man. Paleoclimate and impact of lithospheric dynamics on climate change. Environmental changes in Earth's history and evolution of the human species. Man as an agent of environmental changes. What scenarios for the 21st century? Regional and global environmental changes.

Methodologically, the Biology-Geology and stand-alone Geology disciplines value:

a) The constructivist learning perspective, centered on student learning, not ignoring the important role of the teacher as a facilitator;
b) The History of Science, namely contextualizing teaching and learning strategies with historical examples;
c) Practical work, following a logical line of questioning, valuing completion of diverse activities, from paper and pencil exercises to those requiring a laboratory (e.g. laboratory and experimental work) or other learning environments, such as the field. These should be integrated into the curriculum as open-ended problem-solving scenerios, emphasizing building on previous concepts, formulating and contesting hypotheses, planning and executing activities, and completing representative records;
d) The Science-Technology-Society perspective, exploring real and meaningful contexts for students;
e) Collaborative work, promoting student dialogue and participation, encouraging articulation of ideas and challenging these using scientific models;
f) Using analogical physical models, exploring problems of scale, speed of processes, and representativeness of materials used, as well as discussing the underlying model's hypotheses and limitations, and making a critical evaluation of the results obtained in comparison with the real data;
g) The use of Information and Communication Technologies to support research, data processing, modeling, and communication.

Teachers and students have seven weekly study periods in Biology and Geology to implement this curriculum, three for the practical component, and four dedicated to Geology, two of which are also disrected towards developing pratical activities. Practical classes are split in half whenever students' numbers exceed twenty. The practical component in experimental subjects is worth 30 percent of students overall assessment.

Integrating the recommended curricula guidelines for these disciplines has been a great challenge for teachers and encountered different obstacles.[20] For example, teachers' notions and attitudes about teaching

20. Rebelo, D., Marques, E., & Marques, L. (2005). Formação de professores: contributo de materiais didácticos para a inovação das práticas. *Enseñanza de las Ciencias, número extra*. Available in: http://ddd.uab.cat/pub/edlc/edlc_a2005nEXTRA/edlc_a2005nEXTRAp377forpro.pdf; Rebelo,

the subject and the nature of science (determined in part by their personal experiences); student manuals determine the organization of most classes; the lack of curricular materials that integrate current perspectives into science education; and the difficulty teachers have in articulating dispersed and compartmentalized knowledge as contextualized knowledge.

The conceptions and attitudes of teachers towards the teaching and nature of science are an obstacle to integrating the recommended guidelines into the curricula, insofar as they condition their how they interpret official documents (*e.g.,* programs). These are often interpreted from empiricist epistemological perspectives at the expense of rationalist epistemologies directed at purposes beyond the curriculum.

Thus, to interpret and implement the program directives, teachers need to develop a concetual, epistemological and psychological framework that allows them to appropriate the underlying curricula principles, so that they are able to adopt, adapt and actuate innovative pedagogical practices. Evidence has revealed that the better a teacher understands the curriculum's demands, the greater their professional development. Teacher training is, therefore, an indispensable component of curricular innovation in order to act upon, elaborate, produce and appropriate the discipline knowledge presupposed by the syllabuses.[21]

20.7 Portuguese Geology Olympiads

The 7th edition of the International Earth Science Olympiad (IESO), held in Spain in 2014, had as its theme the sea and mountains. A Portuguese observer participated at this event for the first time. The following year, Portugal debuted with the first team of students, earning a gold and a bronze medal. In 2016, the Portuguese team won two silver and one bronze medals.

The Portuguese Geological Olympiads are organized annually by a National Geological Olympiad Commission of the Geological Society of Portugal (NGOC),[22] with the support of the Ministry of Education,[23] most of the Portuguese Universities, the Agency and Live Science Network,[24]

D. (2014). *Desenvolvimento profissional de professores de ciências: um estudo no contexto da geologia*. PhD thesis (not published). Aveiro, Portugal: University of Aveiro. Available in: https://ria.ua.pt/handle/10773/12920.

21. Sá-Chaves, I. (2007). *Formação, Conhecimento e Supervisão. Contributos nas Áreas da Formação de Professores e de Outros Profissionais* (2.nd ed.). Aveiro, Portugal: University of Aveiro.
22. URL: http://www.socgeol.org/olimpiadas_1.
23. URL: http://dge.mec.pt/.
24. URL: http://www.cienciaviva.pt/centroscv/rede/.

the Azores Geopark[25] and the IESO.[26] The competition is open to 11th grade students in Biology and Geology. It is structured by phases and regions:[27] School Phase, the first student selection phase, conducted in all schools with secondary education; Regional Phase, the second testing phase, including the academic schools of the Centers of Living Science, the Geoparks, and, exceptionally, the Universities clustered by region, North, Center, Lisbon and Tagus Valley Regions and South (including the Autonomous Regions of Madeira and the Autonomous Regions of Azores); Final Phase, the third and last phase of tests, organized by a Portuguese university department,[28] in which students qualify to participate in the IESO on the Portuguese team.

In order for a secondary school, or grouping of schools, to have its students participate in the Portuguese Geological Olympiads, it is necessary for a professor in the disciplinary group of Biology and Geology to show interest in functioning as the link between the NGOC and the school by the end of October each year. This teacher is a responsible professor, with the following functions: *a)* Ensure student enrollments; *b)* Ensure test scripts and answer keys are received for the School Phase; *c)* Manage logistics, namely room appointment and invigilator coordination, for the day and time marked by the Organizing Committee nationally; *d)* Print and distribute statements; e) Correct the tests and communicate results to the Jury of Experts.[29]

All students participating in the Regional and Final Phases receive participation certificates. In the regional phase, gold, silver and bronze medals are awarded to the students in the top three places. In the final phase, special "Olympics" prizes are awarded to the students winning the 1st, 2nd and 3rd places, with honorable mention for 4th place. Since the IESO test content is more comprehensive than that of the Biology and Geology programs, the NGOC defines how additional preparation is done for the hydrosphere, atmosphere and astronomy subjects. Participation in IESO requires that students on the team must cover their travel and accommodation expenses.

25. URL: http://www.azoresgeopark.com/.
26. URL: http://www.ieso-info.org/.
27. URL: http://www.socgeol.org/ckeditor_assets/attachments/170/regulamento_olimpiadas.pdf.
28. In 2017, the schedule is as follows: School Phase (January 27); Regional Phase (April 1); Final Phase (May 20-21). The final phase is organized this year by the University of Évora and the Estremoz Living Science Center.
29. URL: http://www.socgeol.org/ckeditor_assets/attachments/170/regulamento_olimpiadas.pdf.

20.10 Final Considerations

Compulsory schooling in Portugal is 12 years, or for children and young people between the ages of six and 18 years. Basic education is universal and free and lasts for nine years, divided into three cycles. Three years of secondary education follows. Earth science topics are present throughout primary and secondary education. In the first cycle of basic education, Earth Sciences are studied within Environmental Studies, particularly in the 1st, 3rd and 4th grade, with the following themes: “Discovering the natural environment”; “The discovery of the interrelationships between Nature and Society”; “The discovery of the interrelations between spaces” and “The discovery of oneself”.

Earth Sciences are again studied in 5th grade (second cycle of basic education), in the Natural Sciences discipline, with the following subjects: “Soil”, “Rocks” and “Water”.

Natural Sciences, in the third cycle of basic education (7th grade), is entirely dedicated to Earth Sciences. It begins with ”Geological landscapes”, to study next “Drift of the continents and plate tectonics”, “Rock Deformation”, “Magmatism and magmatic rock”, “Genesis of metamorphic rocks”, “Rock Cycles”, “Main Lithological formations in Portugal”, “Seismic activity”, “Contribution of science and technology to study Earth’s internal structure”, “Major stages of Earth’s history” and “Fossils and their importance for the reconstruction of Earth”. It concludes with “Geological knowledge and sustainability of life on Earth”.

Finally, in secondary education, Biology and Geology distributes the Life Sciences and Earth Sciences content equitably. In 10th grade, the following themes are studied: “Geology, geologists and their methods”, “Earth, a very special planet” and “Understanding the structure and dynamics of the geosphere”. The Earth Sciences component in 11th grade is dedicated to “Geology, problems and materials of everyday life”. In 12th grade, the final year of secondary education, three themes are studied: “From the Theory of the Continent to Plate Tectonics Theory: The dynamics of the lithosphere”, “The history of Earth and Life” and “The Earth yesterday, today and tomorrow”.

The Directorate-General for Education prepares the National Curriculum for compulsory schooling (from 1st grade to 12th grade), where the essential curriculum is elaborated for each subject (by discipline / year). The Portuguese Association of Teachers of Biology and Geology was invited to contribute to a proposal that includes the essential / non-essential learning (lessons developed according to the school's context, applied pedagogical differentiation strategies and interdisciplinary communication) of all disciplines that integrate Natural Sciences and Biology and Geology content (1st-4th grade – Environmental Studies; 5th-9th grade – Natural Science; 10th and 11th grade – Biology and Geology; 12th grade – Geology). The work completed refers to the current normative and curricular documents and comes into force soon. Clarifying what is essential or non-essential learning, allows teachers a time window to conduct practical activities and promote more meaningful learning.

In conclusion, Earth Sciences have an appropriate and necessary place in Portuguese non-higher education, with a solid grounding from the earliest ages, passing through a discipline dedicated to this science (Natural Sciences - 7th grade), another that divides the time equally with Life Sciences (Biology and Geology - 10th and 11th grades), concluding with the optional Geology course in the final year of secondary education. It is therefore estimated that at the conclusion of secondary education, a young person is prepared for continued studies in higher education with components of Earth Sciences. At the same time, they are enabled to think and consciously intervene in decision making, to the extent of their possibilities and responsibilities, in every day societal problems, and ethically manage natural resources to preserve the environment as an integral element of the noosphere and Earth's ecosystem.[30]

30. Bonito, J. (1999). Da importância do ensino das Geociências: algumas razões para o "ser" professor de Geociências. In Trindade, V., Fialho, I., Bonito, J., & Cid, M. (orgs.), *Metodologia do ensino das ciências – Investigação e prática dos professores* (pp. 41-55). Évora, Portugal: University of Evora. Available in: http://dspace.uevora.pt/rdpc/bitstream/10174/16541/1/Bonito.pdf.

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Chapter 21

Introduction of Korean Earth Science Education and Preliminary Process for Student Participants in IESO (International Earth Science Olympiad)

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Abstract

The current Korean public science education system started in 1945, and had ten major revisions of the national curriculum in the past 70 years. Since the third revision of the national curriculum (1973-1981), Earth science is taught in equal proportion to each of the other science areas, physics, biology, and chemistry, in the primary and secondary schools. Concepts and topics covered in the Earth science curriculum include the geosphere, atmosphere, hydrosphere, solar system and universe. As an organization of the Korean Earth Science Society (KESS), the Korea Earth Science Olympiad (KESO) takes charge of selecting and preparing student participants for the IESO. The selection and preparation proceeds along two team tracks, national and international. There were five rounds of selection and education for the national team track. The first selection round is based mainly on applicants' school records. After the first round, the number of students is reduced progressively to 60, then 40, 20 and finally 4, through each round of preparation and selection. The preparation processes includes online classes at the second round, four-days of summer camp at the third round, a two-day field excursion at the fourth round, and six days of winter camp at the fifth round. The selection processes includes written and oral tests based on the content included in classes and camp, as well as general Earth science knowledge. The IESO track includes three-month online classes, a six-day summer camp, a two-day field excursion, and four days of classes. The materials for the classes, excursions and camp are directly related to the IESO syllabus.

Keywords: Korean Earth Science Olympiad, Korean Earth Science Society, selection and preparation for IESO, IESO syllabus

21.1 Earth Science Education in Korea

Earth science education in Korea is based on the national curriculum for the primary and secondary school system. Here, the underlying objectives of general science and Earth science are described, as well as a brief history of Earth science curriculum development in Korea. The preliminary procedure for selecting and preparing IESO participants is explained in the following section.

21.1.2 Science Curriculum in Korea

The science component of the National Common Basic Curriculum is designed for all students from grade three to ten. The Science Curriculum aims to help students understand the basic concepts of science through inquiry, with interest and curiosity in natural phenomena and objects, and to develop scientific thinking skills and creative problem solving abilities. Consequently, students are able to develop the scientific literacy necessary for creatively and scientifically solving the problems of daily life.

'Science' is organized in partnership with 'Intelligent Life' for grades one and two at elementary school, and Physics I, Chemistry I, Life Science I, Earth Science I, Physics II, Chemistry II, Life Science II, Earth Science II for grades 11 and 12 at high school. The contents of 'Science' include the domains of motion and energy, materials, life, and Earth and space, linking basic concepts and inquiry processes across grades and domains.

In 'Science' learning is centered around various inquiry-based activities including observing, experimenting, investigating, discussing, etc., depending upon students' abilities. The emphasis is on independent and group activities for nurturing scientific attitudes and communication skills including criticism, openness, integrity, objectivity, cooperation, etc. Teaching also stresses comprehensive understanding of basic concepts rather than fragmental acquisition of knowledge and the ability to solve problems scientifically in daily life using that knowledge.

The core 'Science' concepts are taught with relevance to learners' own experiences and students are provided with opportunities to apply science related knowledge and inquiry skills for problem solving in society and daily life. By learning about science, students are able to recognize the relationships between science, technology and society as well as the value of science.

Students gain the scientific literacy necessary to develop creative and scientifically sound solutions to everyday problems. The objectives of the Science Curriculum are to educate students who can:

1) understand the basic concepts of science and apply them for solving problems in daily life;

2) develop the ability to determine the scientific nature and use it for solving problems in daily life;

3) enhance curiosity and interest in natural phenomena and science learning, and develop an attitude to scientifically solve problems in daily life;

4) recognize the relationship between science, technology and society.

In elementary school, students are usually grouped by age. Teachers are encouraged to place children in small groups and then give them problems they may solve together, rather than relying on whole class teaching. Individual schools also began using open classroom teaching several years ago, in which teachers reduce direct instruction and integrate multiple subject areas into group or individual projects. This method garnered attention after success in independent schools, and is now used by many public schools in Korea, with government support.

At the secondary level, instruction remains fairly traditional, as teachers are concerned with preparing students for university entrance exams. Students are grouped by age, rather than ability, although some junior and senior high schools have introduced ability based grouping in in the past decade. The ministry encourages instructors to use active learning methods in their teaching, including engaging students in science experiments, group discussions, and surveys. There is also a strong emphasis on integrating technology into the classroom. The Ministry of Education has tried to reform upper secondary school instruction to some degree, encouraging teachers to incorporate inquiry based learning and problem solving. Technology continues to be very important.

21.1.3 Current Earth Science Education System

First and second grade students study the subject 'Intelligent Life', which includes the science content about 20 25 percent of which is Earth science knowledge. From third to 10th grade, Earth science is included as one quarter of the 'Science' subject. Earth science is included for 11th and 12th grade students who select the natural science track.

Science is formally introduced to students in 3rd grade. Therefore, Earth science contents is included in formal education from 3rd grade. The major concept or theme of each grade level is as follows:

Grade level	Major concepts or themes
3rd and 4th	Earth and Moon, Volcanoes and Earthquakes, Changes in Earth's crust, Geologic layers and Fossils
5th and 6th	Solar system and Stars, Weather and Our life, Movement of Earth and Moon, Changes of Seasons
7th to 9th	Earth System and Changes in the lithosphere, Atmosphere and Our life, Composition and Cycles of the Hydrosphere, Solar system, Cosmosphere and Exploration of Outer Space
10th	Origin of the Universe, Stars and Galaxies, Solar System Formation, Solar System Dynamics, Planetary Atmospheres, Earth, Carbon Cycles and Climate Changes
11th and 12th (Earth Science I and Earth Science II)	*Earth Science I*: Earth as a Planet (interactions between Earth systems, Earth's environment for living things), Precious Resources of Earth (underground resources, soil resources, atmosphere, hydro resources, future non fossil energy), Beautiful Korean Peninsula (geology and topology of the Korean peninsula), Changes of solid Earth (earthquakes, volcanoes, plate tectonics, weathering), Changes in fluid Earth (weather and ocean data in daily life, cycles of the atmosphere and hydrosphere, inclement weather), Environment pollution (climate changes in Earth's history, causes of climate changes, El Niño, greenhouse effects, the Ozone hole, solutions for environmental changes), Astronomical Observation (star constellation observing and changes thereof, Sun observation, Phase changes of the Moon), Exploration of the universe (space probes, characteristics of celestial bodies in the solar system, space telescopes, exploring the outer solar system) *Earth Science II*: Earth's Structure (Earth's interior, gravity field, and magnetic field), Materials of Earth (rock formation and characteristics), Changes of Earth (Earth's interior energy, plate tectonics, structural geology), History of Earth (fossils, geologic periods, major principles and application of historical geology), Geology of Korea (geologic investigation, Korean rocks, fossils in Korea, formation of Korean the peninsula), Movement and Cycles of the Atmosphere (jet stream and cyclones, atmospheric stability, energy equilibrium and cycles of the atmosphere), Movement and Cycles of Oceans (temperature, density and salinity of oceans, wave and tides, Ekman transfer), Interactions between the Atmosphere and Oceans, Characteristics of Stars (distances from stars, star movements, H R diagram, energy source of stars), Our Galaxy (our galaxy's structure and physical features, interstellar materials), Galaxies and Universes (Hubble's Law, Big bang Theory, dark matter)

21.1.4 A Brief History of Korean Earth Science Curriculum

Earth science education in Korea received increasing interest over the last 70 years (Song and Joung, 2014).

Lecture Syllabus Period (1945 1955)

Earth science did not initially exist as a separate subject. Earth science concepts were taught in other science subjects:, *e.g.* concepts in geology and atmospheric sciences were included in chemistry.

The 1st National Science Curriculum (1955 1963)

The impact of pragmatic education in the US was inclusion of extensive Earth science content related to learners' everyday experiences (*e.g.* underground resources, methods and myths in using almanac, mineral deposits, hot springs, etc.). The separate subject 'Earth Science' was first established at the high school level.

A. The 2nd National Science Curriculum (1963 1973)

Earth science in high school was not on par with other science subjects such as physics, chemistry, and biology. Space, satellites, spaceships, the external world, and space platforms are included as a result of the US' space project.

B. The 3rd National Science Curriculum (1973 1981)

The scholarly focus of US science education became the basis for a substantial change in Earth science education. Earth science was placed on par with physics, chemistry, and biology in the science curriculum for the first time. Such scholarly focus on Earth science content remains today.

C. The 4th National Science Curriculum (1981 1987)

The scholarly focus science education development continued. In high school, students in the liberal arts and science paths had subjects "Earth Science I" and "Earth Science II", respectively. There was little significant change from the previous curriculum.

D. The 5th National Science Curriculum (1987 1992)

The 'public understanding of science' began to influence the curriculum. Science literacy was first reflected in the Earth science curriculum. The 'nature of science' was first included in the content. A lot of environmental topics were added into the Earth science curriculum.

E. The 6th National Science Curriculum (1992 1997)

A full-fledged approach to teaching scientific literacy was adopted. The concepts of ‘the nature of Earth science’ and ‘Earth’s environment’ were reinforced in the Earth science curriculum. An ‘integrated science’ subject was first established in the 10th grade.

F. The 7th National Science Curriculum (1997 2007)

The concept of scientific literacy takes root as a key topic. The ‘system’ concept is adopted into the high school ‘Earth Science I’ unit. All students from grade 3 to 10 are required to learn the same science material.

G. 2007 Revised National Science Curriculum (2007 2009)

Open-ended and student-centered inquiry activities were established in the curriculum. Students were allowed to plan and execute their own full range of scientific inquiry.

H. 2009 Revised National Science Curriculum (2009 Present)

The Big Bang Theory and origins of the universe became the starting point for high school science for all students. Now cosmology and astronomy are considered essential to scientific literacy for all citizens.

21.2 National Team Selection and Preparation for IESO Participant Students

21.2.1 Overview

The selection process for the national team and the training (preparation) program for the IESO are illustrated schematically in Fig. 1 (Cho and Kyung, 2014; Cho and Cheong, 2015). The programs contained in these processes are operated by the Korean Earth Science Olympiad (KESO), which is a sub organization of the Korean Earth Science Society. The whole processes can be classified into two tracks: One is the training/evaluation track to select the national team’s four representatives (for convenience, referred to as national team track), and the other for the national team to prepare for the IESO (IESO track). It takes one and half years for a trainee to complete both tracks. Since the trainees are recruited every year, KESO runs both tracks simultaneously. The national team track includes five training/evaluation programs, while the IESO track includes five training programs. In the national team track, students are evaluated at the end of each training program to those who enter the next, higher level training program. The training programs of each track are designed to cover the whole range of high school level Earth Science, as well as the IESO syllabus. As the IESO track is designed to train the Korean representatives, it provides higher level material than the national team track. Detailed explanations of the two tracks and the sub programs included in the tracks in 2014 are explained below.

21.2.2 National team track

The national team track begins with screening applicants from high school and middle school students based on their scholastic record and potential for Earth science performance. As for middle school students, only senior level students are eligible to apply. National team track hopefuls are invited to apply for screening, which is usually carried out between late April and early May each year. Table 20.1 shows the number of students who applied to the programs in 2014. We had total of 425 applicants, 370 (about 95%) of which passed through the screening process. Although the screening is based on the scholastic achievements, about 5% of sub quota for minorities are chosen without evaluating any scholastic record. Such a guideline for the sub quota is recommended by the Korean Foundation for the Advancement of Science and Creativity (KOFAC), the financial supporter and supervising organization of KESO. The students who passed the screening go through a series of training and the evaluation/selection process. For each program, we invite university professors and professional researchers from Earth Science related research institutes to serve as lecturers and evaluation committee members. The five training programs included in the national team track are: introductory level cyber class, summer school, advanced level cyber class, field work, and winter school (Table 20.2). Each program ends with an evaluation/selection test.

a. Introductory level cyber class

This is the first online training program provided, which continues from the spring semester until the beginning of summer vacation. Fourteen video lectures, for five disciplines comprising the Earth sciences, *i.e*. geology, geophysics, meteorology, oceanography, and astronomy, are produced and uploaded on the KESO homepage. The videos are made available online in order, successively one after the other. At the end of the program, students take a test to select who will advance to summer school. The evaluations are written tests composed of questionnaires prepared by university professors and researchers from Earth Science related institutes. Through this test, 63 students were selected, among which 3 were selected by the sub quota for minorities, as in the first screening process.

b. Summer school

This is an intensive study course presented over three nights and four days. During this period, the students are accommodated at the dormitory of the university that administrates the summer school. A half of the program consists of class room lectures, while another half provides the students with the chance of visiting the Earth Science related institutes. The institute visiting program is run to provide the students with a deeper understanding of the Earth Sciences as well as an opportunity of career development. Four institutes which joined this program are the National Meteorological Satellite Center (NMSC), the Korea Institute of Geoscience and Mineral Resources (KIGAM), the Korea Institute of Ocean Science and Technology (KIOST), and the Korea Astronomy and Space Science Institute (KASI). At the final day of the program in 2014, 40 students were selected through written test who will enter the advance level of cyber class.

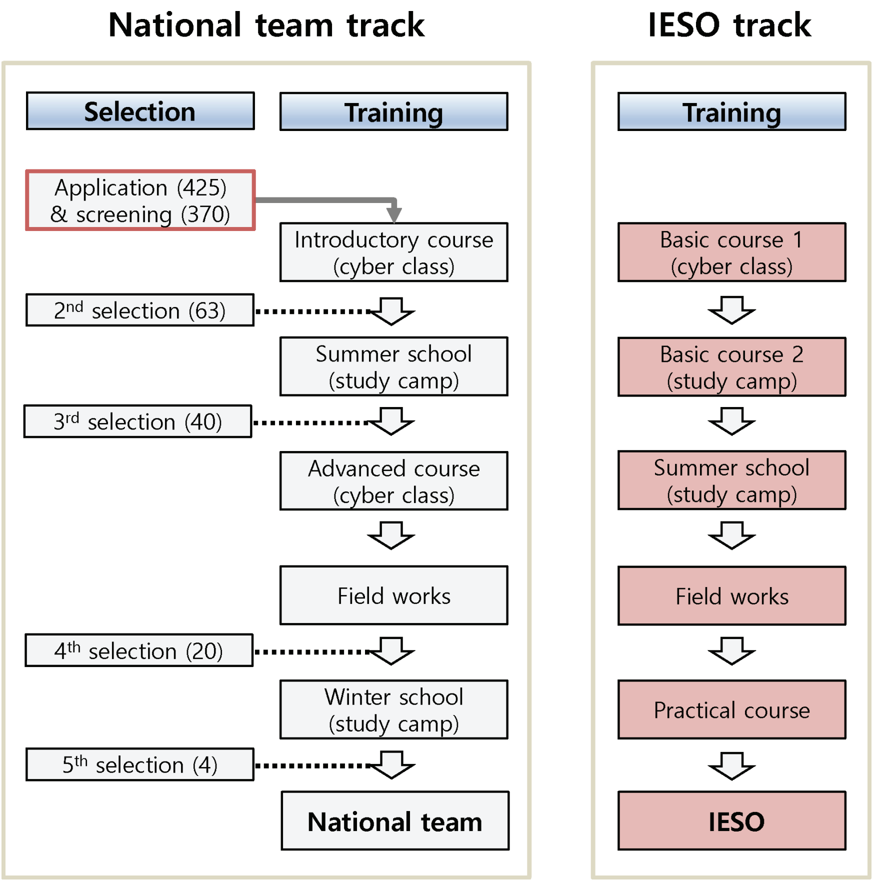

Fig. 21.1 Flow chart showing the national team selection and training process for the IESO

Tab. 20.1 Number of applicants for the national team track

School level	Male	Female	Total
Middle school (only senior students)	33	10	43
High school (general)	137	91	228
High school (science)	118	36	154
Total	288	137	425

c. Advanced level course of cyber class

This is basically the same as the introductory level cyber program except that students are provided with more advanced materials. At the end of the program, students are evaluated for academic competitiveness by both written tests and in-depth interviews. This selected the final top 20 students to advance to the final training course of the national team track.

d. Field work

This program is intended to enhance the top 20 students' ability to perform in geology, geophysics, and astronomy themed field work. Students gain experience in various field methods for those subjects under the guidance of the professors and assistants.

e. Winter school

The finalists are invited to an intensive, one week winter school. It provides 12 hours of classroom lectures per day. Unlike other programs, the winter school includes two class hours of science ethics delivered by a professional in that field. This is to benefit the winter school students, who are considered to have high potentials to become scientists in the future, to understand ethics for scientific researchers. Another class, unique to this program, is four hours of English by a native speaker, intended to help students become more confident communicating in English. On the last day, an evaluation selects the final four members of the national team who will represent Korea in the IESO. As at the summer school, a written test is used in the evaluation process.

Table 20.2 Programs for the national team track

Program	Number of students	Period	Training type	Venue	Contents
Introductory course	370	2014.06.01 -07.20	Cyber class (Video)	KESO homepage	As, At, Ge (hard), Ge (hard), Oc
Summer school	63	2014.08.11 -08.14	Study camp Visit-Institutes	Chungnam Natl' Univ. National Institutes	As, At, Ge, Ge (soft), Oc Institutes (NMSC, KIOST, KIGAM,KASI)
Advanced course	40	2014.09.11 -11.10	Cyber class (Video)	KESO homepage	As, At, Ge (hard), Ge (hard), Oc
Field works	40	2014.11.08 -11.09	Field Geology	Western coastal area, Jincheon, Chungbuk Prov.	Geological survey
Winter school	20	2015.02.23 -02.28	Class-room lecture	Korea Natl' Univ. Edu.	As, Ge (hard), Me, Oc, En

As: Astronomy Ge: Geology Re: Remote sense En: English
At: Atmospheric science Oc: Oceanology To: Topography

21.2.3 IESO track

The IESO track has five training programs: basic level cyber class, advanced level course, summer school, practical course, and field work (Table 20.3). Although the IESO track appears to share the some program names with the national team track, it provides the national team of four representatives with distinct curriculum.

a. Basic level cyber class

This program conveys basic level Earth sciences in a more integrated way than the introductory level cyber program for the national team track. Nevertheless, the classes are divided formally into the five Earth science disciplines, as for the national team track. The program consists of a twelve week cyber class, in which materials for two-hour lectures, which may be lecture notes, assignments, or questionnaires to solve, are distributed to the students a week in advance. One week later, the solutions are provided via the web conference software, which enables real time, face to face communication between the lecturer and students. The lecturers are encouraged to follow the IESO syllabus.

b. Basic level classroom lectures

The lecturers who served in the preceding program are responsible for this course, which is an intense, four day training course. It's aimed at students' comprehensive understanding of the material delivered in the aforementioned course, from a system rather than individual viewpoint. Prior to entering this course, the students are asked to evaluate themselves by checking their confidence on the subjects of the IESO syllabus. The KESO encourages the lectures to fully consider this survey in their lectures, allowing every representative an opportunity to correct any minor misunderstanding.

c. Advanced level course (summer school)

This is an intensive one-week study camp, much the same as the winter school for the national team track. The program consists of only classroom lectures, which cover the five Earth science disciplines.

d. Practical course

This course was established to help the national team students prepare for the practical tests of the IESO. It is designed to provide the students with improved practical skills in the five disciplines through laboratory activities.

e. Field work

This is a course much similar to the national team track field work. Its purpose is to improve the national team students' performance in the field. During this program, students visit a few geological sites for guided field work.

Tab. 20.3 Programs for the IESO track

Program	Period	Training type	Venue	Contents
Basic course 1	2014.03.17-07.15	Web conferencing (Cyber class)	KESO homepage	As, At, Ge (hard), Ge (soft), Oc
Basic course 2	2014.07.25-07.25 2014.07.30-07.31	Class room lecture (Study camp)	Chungnam Natl' Univ. Korea Natl' Univ. Edu.	As, Ge (hard), Me, Oc, Re, To, En
Summer school	2014.08.04-08.09	Class room lecture (Study camp)	Konju Natl' Univ.	As, Ge (hard), Me, Oc, To
Field works	2014.08.14-08.16	Field Geology	Kangwon Province	Geological survey: Youngweol, Sobaiksan, etc.
Practical course	2014.08.27-08.31	Lecture, Laboratory activities,	Chungnam Natl' Univ. Korea Natl' Univ. Edu.	As, At, Ge (hard), Oc, En

As: Astronomy Ge: Geology Re: Remote sense En: English
At: Atmospheric science Oc: Oceanology To: Topography

21.3 Summary

The current Korean public science education system started in 1945 and its curriculum has gone through 10 major revisions in past 70 years. The Earth science curriculum in Korea is designed to help students: 1) understand the basic Earth science concepts and their application; 2) develop the ability to determine the scientific nature and use it for solving Earth science-related problems; 3) enhance curiosity and interest in natural phenomena and develop an scientific attitude; 4) and recognize the relationship between science, technology, and society. Since the third revision of the national curriculum (1973-1981), all science disciplines are taught with equal weight in the primary and secondary schools. Concepts and themes covered in the Earth science curriculum include the geosphere, atmosphere, hydrosphere, and solar system and space.

The KESO runs a series of training and selection programs for the

IESO. These programs are divided into two categories of the national team track and IESO track. The national team track is to select the four Korean representatives among the applicants through education and evaluation, while the IESO track is to train the Korean representatives. Each track consists of five programs that provide the students with classroom lectures, cyber classes, laboratory activities, and the field work experience. In 2014, we had 425 applicants from across the nation. In every program of the national team track, the students are first trained and then examined to advance to the next program. Thus, only a limited number of students attending a program are allowed to go into for the next training course; the number of selected trainees by the end of each training program was 370, 63, 40, 20, and 4. The IESO track basically repeats similar programs, but with higher levels of teaching. Through the practical course, which is unique to the IESO track, representatives develop their practical problem solving skills. To prepare for the IESO, the representatives have the opportunity to develop their weakest part of the IESO syllabus, through self evaluation.

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Chapter 22

Russian Experience of Team Preparation for IESO

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Abstract

Participation of Russian teams in International Earth Science Olympiads (IESO) opens great possibilities for science competitions, communication and experience exchange for school students and teachers. IESO serves important purposes for Russian school education: improved interest in natural sciences, forming a scientific outlook, and identifying talented students. International competitions provide opportunities to compare knowledge and skills of students from different countries and use other country's experiences to upgrade Russian national Earth Science education programs.

Preparation of the Russian IESO team is based on an extracurricular system. Traditionally, in many Russian cities there are a lot of geological, ecological, astronomical, archeological and others clubs and associations for school students who are keen on science. Now many Earth science clubs bring their educational programs in line with the IESO syllabus. The selection of participants and formation of the Russian IESO team occurs at the oldest Geological club in Russia, belonging to the City Palace of Youth Creativity, and at the Geology and Geoecology Department of Herzen State University in Saint Petersburg.

Russian teams have participated in the IESO from 2010 to 2015. Twenty-four school students from different Russian cities were team members, eighteen of whom won medals. All participants who completed school are now Earth science university students.

Keywords: Russian IESO team, Russian extracurricular education, geological Olympiad, Herzen University. geological school clubs, school science association

22.1 Earth science at Russian school

Russian school education lasts for 11 years: four years at a primary and seven years at a secondary school. The first exposure to Earth sciences begins in primary school from the subject of "Nature study" or "The world around you". They briefly examine different parts of natural science: the planets and moons of the solar system, the Earth's geographical characteristics, the basic properties of water, air, soil, minerals and rocks. It also contains information about plants and animals. In the fifth form, the natural science program includes material necessary to understand natural organic and inorganic processes. Education at this level expands on the knowledge obtained in primary school, exploring questions of matter composition and properties of water, air and soil. Attention is given to questions of living organisms and humans as part of organic nature.

From sixth and seventh grade, school students begin to study geography, biology, physics and chemistry as separate disciplines, but there is no astronomy in school curricula. The school geography lessons focus on physical geography, divided into orography, oceanography, meteorology, and climatology, and biogeography, which includes the geography of plants and animals. Moreover, geography lessons contain some topics of geology, geodesy and cartography, and environmental science, while physics lessons contain basic astronomy. Elements of geology are studied in sixth grade only, while the basics of meteorology and oceanography are studied in sixth and seventh grade. This course covers a fairly wide range of topics. For example, sixth grade students consider the structure of Earth's crust and lithosphere, tectonics of lithospheric plates, volcanic activity, rocks and minerals, and the major landforms of Earth's surface and ocean floor. The main topics for seventh grade are: the origin of continents and oceans, atmosphere and climate zones, distribution of precipitation, oceanic water and ocean currents, interactions between the oceans, atmosphere and lithosphere, as well as the relief and minerals of each continent. Unfortunately, there are only a few lessons a year on these subjects, and the school program does not revisit this part of Earth science in high school at a higher level.

Eighth and ninth grade students study the physical and economic geography of Russia. Only school graduates continuing onto University geography faculties, however, must take a final exam in geography. As a result, a typical Russian school student has relatively low level knowledge of Earth science that does not satisfy the IESO requirements. At the same time, it is clear that fundamental geography and geology understanding is the necessary basis for the modern human worldview. The Earth sciences exchange framework must now be considered an integral mechanism for our planet; only in this way we will find the complex solutions to Earth's problems.

22.2 Russian Extracurricular Education System

Preparing the Russian IESO team is done through an extracurricular education system. Many Russian cities traditionally have many geological, ecological, astronomical, archeological and other science clubs and associations for school students. Their activities connect with regional features: Ural clubs focus on mineralogy, central Russia on paleontology, the Northwest region on mineral resources, etc. Local governments provide financial support to these organizations, and they look for grants and sponsors themselves. Scientists, university teachers and senior students are lecturers for the clubs. Usually, club members have theoretical lectures and practical lessons during the school year and field trips during vacations. Many Earth science clubs now bring their syllabuses into line with the IESO program. There are several local and nationwide scientific competitions and Olympiads in Russia: the Ministry of Education organizes Olympiads on school subjects, while scientific clubs, with the support of universities, organize Olympiads on geology, environment and astronomy. For example, once every two years, the Russian Geological Society organizes federal geological competitions, or "Geological Meetings". The main objective of these competitions is examining practical work in mineralogy, petrography, geological mapping, radiometry, hydrogeology, working with geological compasses, and research. The Russian State Geological Prospecting University organizes the "Earth and Human" themed Geological Olympiad. Moscow State University and the Saint Petersburg Club of Young Geologists organize two concurrent annual Open Geological Olympiads, to examine theoretical geology knowledge. Information is available in Russian at: http://rosgeo.org/olimpiada.html, http://www.geoland.ru/olympic/, http://www.anichkov.ru/page/geology/

22.3 Saint Petersburg Club of Young Geologists

The oldest Russian geological club for school-age children is the Club of Young Geologists (CYG), named after V.A. Obruchev. It has operated an extracurricular educational organization in Saint Petersburg since

1948, the Palace of Youth Creativity. The Club educational environment is unique in Saint Petersburg, with direct access to the interactive "discovery" techniques of world famous natural science museums, but differs in providing live communication with teachers. The Club has close connections with the Geological Faculty of Saint Petersburg University and other geological organizations. The teachers are specialists in different areas of geology. They are often Club graduates, providing excellent teaching, preserving and developing traditions, and facilitating the handover from one generation of teachers and pupils to the next. The Club has a high quality education base and rich geological education museum.

The current Club complex education program concept is as follows:

1. Geological literacy is the essential hallmark of educated 21st century humans;
2. Student-led research is an effective instruction method;
3. Pursuit of a hobby is the way to choose a profession;
4. Educational activity and travels are the way to personal socialization.

Club members' research projects won many prizes at different geological Olympiads: Russian Geological Olympiad "Earth and Human", Saint Petersburg Open Geological Olympiad.

Pupils can begin their education in the Club from the age of eight. The full educational program consists of several consecutive courses designed for seven years. It includes grounding in some age-appropriate geological disciplines. Third to fifth grade novices study programs on "Dinosaurs", "Interesting Geology" and "General Geology" that introduce children to the world of geology and awaken their interest in the world around them. After that, pupils choose more specialized courses such as, "Field geology", "Mineralogy", "Paleontology" or "Natural recourses". They can also choose from basic, advanced or professional level oriented educational program. Each course corresponds with the age and educational level of pupils. The programs consist of theoretical and practical lessons, excursions to the Saint Petersburg geological museums and geological sites in the Leningrad region, and individual research projects. Moreover, children have opportunity to take part in such specialized areas as, "Stone arts", "The basis of research work", "Colored stones", and "Architectural rocks in city".

Summer field trips are each student's favorite part of their education. The Club organizes training expeditions in the area surrounding Saint Petersburg for younger students and to different Russian regions (*e.g.* Karelia, Ural Mountains, Volga river, etc.) for older students. They study geology and the local environment and collect mineral and fossil samples. These materials form the basis for student-led research (Figure 22.1).

Fig. 22.1 Summer field trips of the Saint Petersburg Club of Young Geologists: a) searching for Ordovician fossils, Saint Petersburg area, 2010; b) study of Proterozoic migmatites, Karelia, 2007; c) study of karst processes, Msta river, Novgorod area, 2013; d) location of the first diamond discovery in Russia, Ural mountains, 2008.

The Open Geological Olympiad occupies a special place in the Club's work. The Club and Geological Faculty of Saint Petersburg State University organized this event for 33 years. About 200 students from many Russian cities, who study in local geological clubs and associations, participate in the Olympiad each year. Since 2001, the best student research project theses are published after the Olympiad. Participants conduct several theoretical tests and practical tasks during the intramural stage of the competition. The practical tasks include: recognizing minerals and rocks, identifying fossils and determining their age, reconstructing geological processes, working with geological maps, measuring the strike and dip of rock layers, etc. (Figure 22.2)

Fig. 22.2 The annual geological Olympiad, Saint Petersburg: a, b) working with geological maps and compasses, 2013 and 2015; jury members A. Savelev and M. Kurapov were participants of first Russian team for the 2010 IESO; c, d) identifying minerals and fossils, 2013.

(copyrighted photos)

The outcome of the Saint Petersburg Open Geological Olympiad forms the basis of the selection process for Russian IESO teams.

22.4 Selecting Russian Team Members for the IESO

The process to select the national team is as follows:

Step 1. Students compete in local clubs; winners proceed to step 2.

Step 2. The Saint Petersburg Geological Club organizes the annual Open Geological Olympiad, in the City Palace of Youth Creativity. Participants take part in live theoretical conversations, tests, and practical tasks. Moreover, they present their own scientific projects or investigations. High school participants have additional tests in geography, meteorology and astronomy questions as a selection stage. Ten winners from tenth grade (usually 16 years old) go to step 3.

Step 3. Final team selection occurs during the Summer school "Geology and Civilization" at Herzen State University. Over four days, the candidates listen to lectures and have practical lessons from Herzen University teachers on geology, geophysics, meteorology, oceanography, ecology and astronomy. Students participate in fields trips, master classes, brain-rings, conferences, and excursions in the Summer School framework. After that, the candidates have three final written tests in geology, meteorology and hydrosphere, and astronomy, and a practical geological field test near Saint Petersburg. Four winners are selected to form the team (Figure 22.3).

Fig. 22.3. Final stage of team selection: a) theoretical written test at Herzen University, 2011; b) field trip to the Vyborg granite massif, 2012; c) practical geology test, E. Tikhova won the competition and joined the 2012 IESO team; d) winners of the Saint Petersburg Open Geological Olympiad were candidates for IESO team, 2015.
(copyrighted photos)

We successfully followed this process from 2011 to 2014. Unfortunately, in 2015 the final selection at Summer school was replaced by remote training and Internet-based tests due to financial difficulties.

Russian teams have participated in IESO from 2010 to 2015. Teams were composed of twenty-four school students from different Russian cities, winning one silver medal and seventeen bronze medals. All participants who completed school are now university students, and have chosen Earth science faculties (Table 22.1).

Tab. 22.1 History of Russian participants

	Name	Home town	Award	Present status
2010	M. Kurapov	Saint Petersburg	Bronze	Saint Petersburg State University, geological faculty
	A. Shurunov	Saint Petersburg	Bronze	Saint Petersburg State University, geological faculty
	A. Saveliev	Saint Petersburg	Bronze	Saint Petersburg State University, geological faculty
	N. Pravdina	Saint Petersburg	-	Saint Petersburg State University, geography faculty
2011	A. Turin	Perm	-	Perm State University, geological faculty
	R. Anisimov	Saint Petersburg	Bronze	Saint Petersburg State University, geological faculty
	A. Chechenova	Rybinsk	Bronze	Saint Petersburg National Mineral Resources University
	I. Chayka	Novosibirsk	Bronze	Novosibirsk State University, geological faculty
2012	D. Morozov	Novosibirsk	Bronze	Novosibirsk State University, geological faculty
	A. Karamyshev	Rybinsk	Bronze	Saint Petersburg State University, geological faculty
	E. Agafonova	Arkhangelsk	Bronze	Saint Petersburg State University, geological faculty
	E. Tikhova	Saint Petersburg	-	Saint Petersburg State University, geological faculty
2013	O. Kotova	Saint Petersburg	Bronze	Saint Petersburg State University, geological faculty
	A. Vasilev	Perm	Bronze	Perm State University, geological faculty
	M. Serebriakova	Orsk	Bronze	Moscow State University, geological faculty
	E. Brodnikova	Gubakha	-	Novosibirsk State University, geological faculty

2014	E. Generalova	Saint Petersburg	Bronze	Saint Petersburg State University, astronomy department
	A. Sorokina	Gubakha	Bronze	Tomsk Polytechnic University, geological faculty
	I. Bazhin	Perm	Bronze	Perm State University, geological faculty
	K. Dubinin	Orsk	Bronze	Moscow State University, geological faculty
2015	A. Borisenko	Moscow	Silver	Moscow State University, geological faculty
	D. Diageleva	Perm	Bronze	Moscow State University, geological faculty
	V. Kovalev	Novosibirsk	Bronze	Moscow State University, geological faculty
	M. Valinkin	Rybinsk	-	Moscow State University, geological faculty
2016	P. Kurpas	Saint Petersburg	Bronze	MGIMO University
	D. Sotnikova	Gubakha	-	Moscow State University, geological faculty
	E. Tashkinov	Rybinsk	-	Perm State University, geological faculty
	I. Kuzmin	Novosibirsk	-	is preparing to enter university

These results show preparation for and participation in scientific competitions are a very important determining factor when students choose a profession. IESO attracts attention of young people, their parents, and teachers to Earth sciences, expanding their knowledge and realization of new social activities. The IESO purposes such as improving natural sciences interest, forming scientific world views, and identifying talented students are important for Russian school education. International competitions provide an opportunity to compare the knowledge and skills of students from different countries and use other country's experiences to upgrade the national Earth Science educational programs.

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Chapter 23

Current state of Geology Teaching in Spain

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Abstract

This paper deals with the current state of Geology in compulsory secondary education and high school and is divided into the following sections: a) discussion of the current status of geology teaching in compulsory Secondary Education; b) disseminating the actions undertaken by the Commission on "what geology should be taught", whose main objective is defining the "framework for Geoscientific literacy principles" to be taught in Spanish Secondary Schools; c) the Spanish Earth Science Olympiad.

Finally, some recommendations are suggested based on these sections. But these reflections are worthless if we fail to understand that changing the way Geology is taught must include modifying the methods applied for its teaching (Fermeli *et al.*, 2011). It is obvious that we must change to more active and efficient teaching, involving Geology students and teachers in a new learning approach. Geology must be perceived as an interesting (something with a personal impact that remains a part their own personal heritage) and fun (not boring) subject.

Key words: Spanish education, teaching geology, Spanish Earth Science Olympiad, hypotheses and recommendations.

23.1 Introduction

Over the past few years, several reforms were implemented in the Spanish compulsory education system. The most recent reform was the General Education Act (LGE, in Spanish) which raised the age of compulsory education from 14 to 16 years.

The latest changes in education legislation were unfavorable for geology. At the same time, the limited geological content (compared to other sciences) in Secondary Education textbooks decreased the number of students taking these subjects. Additionally, as Geology is included within the broader "Natural Science" subject, it is not taught well or at all. Furthermore, as subjects with geological content in High School are optional and play little importance in the University Access Tests for most degrees at most universities, many secondary schools do not even offer them.

It is necessary, therefore, to analyze geology teaching in pre-university education. The following scenarios will be explored in depth:

a) The current situation of Geology teaching in compulsory education;

b) Dissemination of the proposal "What Geology topics to teach in secondary education";

c) The Spanish Earth Science Olympiad.

It is also important to consider the geological content of the Organic Law on Improvement of Education Quality (LOMCE, in Spanish) approved in 2013. One of its aims is to improve pupils' outcomes, including those in science subjects. In Spain, scientific competence is separate from mathematical competence and is called "competence on knowledge and interaction with the physical world". This competence is related to autonomy and personal initiative, in either life or knowledge (health, science, technology, etc.).

The LOMCE defines curriculum as the elements regulated to determine the teaching and learning processes for each subject. The curriculum cromprises the main learning aims of each subject and education level as well as all knowledge, abilities, and attitudes that contribute to gaining competence.

According to this law, Spain's government takes responsibility for designing the basic curriculum, including learning aims, competences, content, learning standards, and outcomes. It also establishes the assesment criteria to provide appropriate academic titles.

Teaching Geology at these compulsory education levels is now a real challenge for teachers as well as a social responsibility to develop "geological literacy".

We also assess the recent relevance of such Geoscience matters as crystallography, mineralogy and petrology, and offer some final considerations.

23.2 Analysis of the current geology teaching situation in compulsory education

Education in Spain is compulsory for students under the age of 16 (LOE, 2006). These studies are organized in three phases, as indicated in Figure 23.1.

23.2.1 Primary Education (6 to 12 years)

Some basic geological content is scattered in the subjects “Natural sciences” and “Social sciences”. This content refers mainly to Earth’s materials. Despite the the fact that successive PISA reports emphasize in the need of Science, Maths and Language being considered fundamental subjects, in Spain, Science is not considered like this as Maths and Language are (https://www.oecd.org/pisa/pisa-2015-results-in-focus.pdf).

23.3.2 Secondary Compulsory Education or ESO (12 to 16 years) and Bachillerato (Higher Secondary Education 16 to 18 years old)

Science is compulsory for the first three years and represents about 18 percent of the total teaching hours. The first year includes only one scientific subject called “Biology and Geology”, while “Physics and Chemistry” complete the second year (Figure 23.1). Geological content represents about 30 percent of the first-year Biology and Geology curricula.

The LOMCE was implemented in 2013 by a right-wing government in the middle of a serious economic crisis. This law is only a reform of the previous Organic Law of Education (LOE, in Spanish). It retained the spirit of the previous LOE, but some changes were made to content, competences, assesment criteria, and learning standards.

According to this law, the subject “Biology and Geology” is compulsory for all students in the first and third courses of ESO and optional in the fourth course. This subject is also compulsory in the first course of Bachillerato, but only for students who choose to pursue a science career. In the second course of Bachillerato, this subject splits into two separate subjects, Biology and Geology. In this course, science students must choose two of the following subjects: Biology, Technical design II, Physics, Geology, and Chemistry.

It is evident that a Science student can earn the title of Bachillerato without studying any Geology at all.

According to the LOMCE, the subject “Biology and Geology” should contribute to one’s basic knowledge and ability to become a scientifically literate citizen. Students should also become active agents influencing and preserving the environment.

The subject “Biology and Geology” in the 4th course of ESO is divided into four sections: two are dedicated to Biology, one to Geology, and the fourth to either a biological or geological research project, depending on the teacher. By the end of the 4th ESO, students should have learnt the scientific method strategies. They should also have good reading, oral expression, public discussion, and audiovisual communication abilities. They are also expected to know basic lab safety measures.

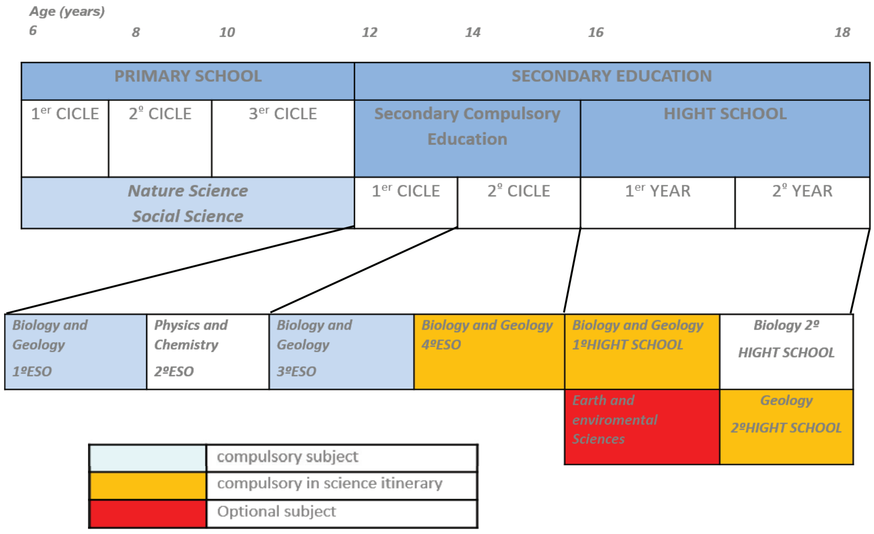

Fig. 23.1 Comparative analysis of curricula in Spain

The topics related to Geology in "Biology and Geology" in the third year of ESO comprise external geological processes and sedimentary rocks. Geological topics of the fourth year include traditional content: origin and structure of the Earth, Earth's dynamics (internal processes), Earth's materials, Earth's history, etc.

In "Bachillerato" (16 to 18 years) the core subjects (Figure 23.1), which include geological content are: "Biology and Geology" in the first year and "Earth and Environmental Sciences" in the second year. We must remember that this phase is divided into two years: First and Second year of Bachillerato, or different models in the various Autonomous Regions (Ministry of Education and Science, 2007b). Furthermore, since 2008, all first-year students must take another compulsory subject, "Science for the Contemporary World". This subject includes 15 percent geological content (Pedrinaci, 2008).

23.3 Dissemination of the current proposal on "which geology to teach in secondary education"

Despite the reduced hours devoted to science subjects, the committee did not review the volume of content included.

In May 2011, a Committee to determine "What Geology should be taught in compulsory education and Bachillerato" started. The aim is for consistent, updated and educational curricular proposal for teaching geology in ESO and Bachillerato, which takes into consideration social and educational requirements and has maximum support from the relevant organisations and institutions related to Geology and its teaching. The purpose is to become a necessary reference for education authorities and non-university science teachers.

The first step of this Committee, composed of 18 geological institutions, was to define the "framework of principles for Geoscientific literacy", which should be taught in Spanish schools for compulsory education. The Committee agreed, submitted and disseminated a "Manifesto for scientific literacy", which aims at acknowledging the relevance of scientific content and the role of Geology in general.

23.4 Master's of Teacher Training

During the 2009-'10 course, the Master's of Teacher Training for Secondary Education was introduced in Spain. It is necessary to have this Master's degree to be a teacher in Secondary Schools, Vocational Schools, and Art Schools, as well as for teaching Offical Languages.

Most Universities in Spain, both private and public, offer this degree comprised of 52 to 69 ECTS, orabout 1500 hours (ECTS stands for European Credit Transfer System, the system that garantees the homogeneity and quality of the studies offered by the different European Universities). To apply for this advanced degree, it is necessary to have a degree issued by a Spanish or European university. Usually, the degree and Master's are in the same subject. For example, the Master's of Biology and Geology is open to graduates of Biology, Geology, Environmental Science, Oceanography, Biochemistry, Pharmacy, Medicine, and Veterinary, as well as for the Engineers in Agriculture, Forests, Mines and Geodesy, and Cartography.

The content of this Master's includes psycho-pedagogical aspects, specific training in the chosen subject, and a short period of Secondary

School placement. For the speciality of Biology and Geology, the geological component is quite small, however, it is an excellent opportunity to enrich the disposition of the future teachers.

The aim of the Master's is not only to train teachers that can cope with educational situations, but also to train experts in reflection, problem solving, investigation, and innovation, so they will be able to better prepare the next generation's students for future challenges. The course is divided in three sections:

- General teacher training (psycho-pedagogical content);
- Subject specific teacher training; and
- Secondary School teacher placement.

The second section (subject specific training) offers a limited geological foundation. The syllabus includes the following compulsory subjects:

- Learning and teaching Biology and Geology;
- Complementary knowledge on the subject (Biology and Geology);
- Teaching innovation and introduction to educational investigations in Biology and Geology.

We consider it a priority to help teachers to introduce Geology in their lessons as a very attractive subject full of potential.

23.5 The spanish earth science olympiad

The first International Earth Science Olympiad (IESO) took place in Seoul, Korea in 2007. The first attempt to conduct a Spanish Olympiad took place in the Basque Country in 2009, organized by the University of the Basque Country. The next year (2010) the first Spanish Earth Sciene Olympiad took place in Madrid. Since then, every year the Spanish Olympiad transpired in a different Spanish city: Madrid (2010 and 2011), Santander (2012), Girona (2013), Toledo (2014), Alicante (2015), Jaca (2016) and Béjar (2017).

There is a National Committee, coordinated by the Spanish Earth Science Teachers Association (AEPECT). Other institutions and companies that support and fund the Spanish Earth Science Olympiad are the Geological Society (SGE), which is the main partner, the Geological and Mining Institute of Spain (IGME), the College of Geologists (ICOG), and the Conference of Deans of Geology.

The progress of this activity has been better than expected: from 600 students in the first edition (2010) up to about 3,000 in 2017, from 270 schools. In the last years, hundreds of secondary teachers and Earth scientists have helped organize these events.

Among the many benefits of the Spanish Earth Science Olympiad, we would like to highlight the following:

- It puts secondary teachers in contact with university teachers and scientists, thus updating the teacher's scientific awareness.
- It encourages secondary teachers to teach more and better Geology.
- It puts students in contact with Geology, thus increasing the number of Science students, especially in Geology.

The main goal of these Olympiads is to raise pupils' interest in Geology, awareness of its importance in the real world, and to promote its progress and dissemination by increasing the number of Geology students at universities. This activity is breaking down the barrier between the scientific and university worlds and that of secondary education. Therefore, the enthusiasm of so many volunteers has inspired a growing number of scientists and institution with the Olympiads.

The Spanish Geology Olympiad has three succesive phases: local, national and international. The local Olympiads are organized by a local committee and they are coordinated by a national committee. The test is divided into two parts:

- Part 1 (individual): solving theoretical test questions (usually 30 questions; worth 2/3 of the total);
- Part 2 (in geographical teams): solving an applied problem with the format of a gymkhana (worth 1/3).

More information at: http://www.aepect.org/olimpiadasgeologia/index.htm

The Geology Olympiads are not only a test, but also a good opportunity to get secondary students and teachers closer to Earth science. So, along all the phases, several additional activities are conducted: workshops, field trips, guided museums visits, lectures, geo-gymkhanas, visits to advanced research centres, etc.

THE SPANISH GEOLOGY OLYMPIAD

In its **first edition (2010),** only 11 local districts were represented by 600 students in the local phase. Thirty-six students went on to compete in the Spanish Olympiad in the facilities of the Universidad Complutense of Madrid (Figure 23.2).

Fig. 23.2 Group of participants in the 1st Spanish Geology Olympiad together with their teachers

The **second edition** started with 1000 students involved in 20 local Olympiads. The 72 students that reached the final phase of the Spanish Olympiad did their tests at the Science Museum (CosmoCaixa) of Madrid. The four winners of this phase travelled to Modena, Italy to participate in the 5th International Earth Science Olympiad (IESO) in September 2011, representing Spain for the first time. This team won a silver medal, a bronze medal and a special mention.

During the local phase of the **third Geology Olympiad,** 89 students were selected from more than 1,700 pupils from 24 districts. The final phase took place in the Palace of La Magdalena, in Santander. The four winners participated in the 6th IESO in Olavarría, Argentina, where they won two bronze medals.

The **fourth edition** of the Spanish Olympiad took place in March 2013, in Girona. The 88 finalists were from 27 different local Olympiads. The total number of participants was about 2,300. The four winners participated in the 7th IESO in Mysore, India and won two bronze medals and three recognition diplomas.

In March 2014, the **fifth Spanish Geology Olympiad,** gathered 90 finalists in Toledo. They were selected from among more than 2,500 students from 25 local Olympiads. The 8th IESO took place in Santander, Spain from the 22nd to the 29th of September 2014. More than 100 students from about 30 countries competed in the facilities of the International University Menendez Pelayo (UIMP), in the Palace of La Magdalena. More information about this event is at: https://www.ucm.es/ieso2014/information.

After the local phases of the **Sixth Geology Olympiad,** with 2,474 students participating from 35 districts, the final phase took place in the facilities of the University of Alicante, Spain, with the 105 students selected in March 2015. The Spanish Team that travelled to Poços de Caldas, Minas Gerais, and Brazil won two bronze medals and two recognition diplomas for the International Team Field Investigation and Earth System Project (ITFI and ESP, respectively).

In **2016** the final phase of the **Spanish Olympiad** took place in Jaca (Huesca). The 84 participants were the winners from the 37 ditricts in the previous phase. The total number of students involved was almost 3,000. The mentor teachers in Jaca had the oppoortunity to enjoy a field trip on which they followed part of the Geological Trans-Pyrenean Route, the first international route across France and Spain (http://www.routetranspyreneenne.com/home.php?seccion=home_sp).

The 10th IESO was celebrated in Mie, Japan in August 2016. Twenty-six teams from all populated continents participated and the Spanish Team had its best performance: two mentions for ITFI and ESP, as well as one bronze medal, one silver medal, and one gold medal. Our golden medalist, Víctor Haro from Instituto de Enseñanza Secundaria Juan de Aréjula in Lucena, Córdoba, was the only European student to win such a medal. More information is at: http://aepect.org/Resena_Informacion_IESO_2016.pdf.

In 2017 the district phase was January to February, with about 3,000 students. The Spanish Olympiad was organized in Béjar, Salamanca, with 84 participating students selected from the 37 district Olympiads (Figure 23.3).

Fig. 23.3 Group of participants in the 8th Spanish Geology Olympiad together with their teachers.

Table 23.1 summarizes the results and awards obtained in the previous International Earth Science Olympiads by the Spanish Team.

Tab. 23.1. Spanish Team IESO results

Year	Gold Medals	Silver Medals	Bronze Medals	Diplomas
2011		1	1	Ability to work cooperatively.
2012			2	Best conclusions in the field work.
2013			2	
2014		1	2	Best scientific research. Best presentation of the work.
2015			2	ITFI* ESP* research
2016	1	1	1	ITFI* ESP* research

* ITFI: International Team Field Investigation
* ESP: Earth System Project

Statistical Data and Analysis of Careers Followed by Student Winners after Their Participation in the Olympiads

Tab. 23.2 Participation data for the District phases and Spanish Olympiads over time

Year	Venue	District Olympiads	Spanish Olympiad	Number of districts
2010	Madrid	600	36	11
2011	Madrid	1000	72	20
2012	Santander	1700	89	24
2013	Girona	2300	88	27
2014	Toledo	2500	90	30
2015	Alicante	2474	105	35
2016	Jaca (Huesca)	2966	84	37
2017	Salamanca	2843	84	37

When analyzing the academic and profesional perspectives of the finalists in the Olympiads (Table 23.2), we appreciate that the prefered profession is Medicine (43 percent of students want to pursue this career). Nevertheless, the second most frequently selected option is Geology (29%). Another remarkable aspect is the fact that since initiating the Spanish Geology Olympiad, the number of Geology students has increased regularly. The remaining Geology Olympiads finalists chose to study either Physics, Biology, Civil Engineering, or Environmental Science, each with less than 10% of students.

When considering that Geology careers are among the least popular for students in Spain, and that is not usually selected by the most "briliant" pupils, it is good news that nearly a third of the Geology Olympiads winners choose to study Geology. Therefore, we conclude that the impact of the Geology Olympiads among Spanish students is certainly positive. Due to the increasing level of students starting Geology studies, we the overall level of Geology in Spain to rise with a very positive societal impact.

23.6 Investigating and Divulging Earth Science Teaching

There is a consensus in the fact that the pre-university education must provide all students with a basic foundation that allows them to know, appreciate and participate in answering all questions affecting their daily life, and that Geology should have a preeminent position, not only to increase public understanding, but also to promote vocations and provide the necessary professional replacements. It is, therefore, essential that the educational syllabus in Spain grant Geology the place it deserves in our society.

Several Spanish associations, such as the Spanish Earth Science Teachers Association (AEPECT) and the Spanish Geological Society (SGE), claim that the social perception of Geology in our country is far from appropriate. It is in this spirit that these associations are promoting their own publications or supporting activities organized by other associations, for the past eight years.

The Geo-days are a Geology promotional initiative across the whole of Spain. They are coordinated by the Spanish Geological Society, with the support of the Spanish Earth Science Teachers Association and the Geological and Mining Institute of Spain (Crespo-Blanc, et al., 2011). They started on a very small basis in the province of Teruel in 2005. They consist of a field trip guided by teams of geologists. Now, there are simultaneous Geo-days in every Spanish Province to increase their visibility in the media. These field trips are open to everybody, no matter their previous geology knowledge (Fig. 23.4). The main aims of these activities are: a) observing the local surroundings through "geological eyes" and understanding the effects of some geological processes acting in and upon the Earth's surface; b) discovering and knowing our geological heritage and raising awareness of its importance and the need to protect it; c) sharing what geologists do and appreciating how they, as scientists and professionals, contribute to a better society and public welfare. The success of the last events, with more than 6,000 people enjoying Geology across Spain, and their intentions to participate in future events, encourages us to continue in this direction to make the Geo-days the annual festival of Geology. More information is available at: (http://www.sociedadgeologica.es/divulgacion_geolodia.html).

Fig. 23.4 Group of participants in the 6th Geo-day in Guadalajara (2014)

Another successful promotional initiative is Sciencee in Action, a science competition throughout the whole country. The next edition, in 2017, will the the 18th. It has several categories, including: a) science teaching materials; b) articles about science communication; c) science performances; d) science videoclips; and e) science lab experiments. Awards went to several geologists previously in several categories.

Finally, we mention other initiatives gaining momentum, for example:

o Be the godfather of a rock: a strategy for protecting the geological heritage to involve society in geo-conservation: http://www.geologiadesegovia.info/apadrinaunaroca/
o Geo-gymkhanas in Alicante for ESO students (Figure 23.5)
o Publishing geological promotional materials
o Collaboration with museums and associations
o Training courses, lectures: Secondary students/teachers visiting universities ("Science Alive", "Science Immersion Week", "Earth Science Days", "Geobizirik – Geology Alive", etc.)
o Program of University visits
o Program of external visits; Lectures by Geology teachers about en-

gaging topics performed in Secondary Schools ("Geology in the Newspapers", etc.)

o Promoting talks about geological truth

o 100 Geo-sites: an initiative of the Institute of Geoscience, together with Universidad Complutense of Madrid (UCM) and Centro Superior de Investigaciones Científicas (CSIC). They have gathered 100 interesting geological sites through Twitter to later promote a contest to choose the top 10.

Fig. 23.5 Geo-gymkhanas in Alicante for ESO students (2014)

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Chapter 24

Earth Science Olympiad Competition and its Influence on Geoscience Promotion in Sri Lanka

Ashvin Wickramasooriya

Abstract

The Sri Lankan National Earth Science Olympiad competition was initiated in 2009. As Geoscience / Earth Science is not included as a main subject in school level curriculum, students did not respond well and only 38 students representing 21 schools applied for the competition when it was organized in 2009. There were only simple multiple choice questions related to Geography, basic Geology, Environmental Science, and Astronomy included in the exam paper. The Earth Science Olympiad competition was the first such experience for students and the lacked general awareness of Geology. Therefore, they did not perform well. However, based on the results, the four best students were selected to represent the Sri Lankan team to participate at the 3rd International Earth Science Olympiad (IESO) in Taipei, Taiwan September, 2009. It was a very useful experience for both students and Sri Lankan Earth Science Olympiad competition organizers. The 3rd IESO is considered the turning point for promoting Earth Science Olympiads in Sri Lanka. With the experience gained Taipei, the Sri Lankan National Earth Science Olympiad organizing committee was able to introduce a new syllabus and structure to the national examination paper.

The Geological Society of Sri Lanka publicizes the Earth Science Olympiad among school teachers and students, and has organized the Sri Lankan National Earth Science Olympiad annually since 2009. The number of candidates participating in this competition has increased each year. Presently, the national competition is organized in nine examination centers covering 24 districts in every province of Sri Lanka. Students who perform well at the provincial level are interviewed to select the top four students to

represent Sri Lanka at the IESO. The Sri Lankan team has participated in the IESO annually since 2009. Since introducing the Sri Lankan National Earth Science Olympiad, students' interest in participating in this competition has increased. By preparing for the competition, students must utilize Geoscience related materials to study the basics of relevant topics. This process has increased students' interest in learning Geoscience.

Keywords: curriculum, IESO, Geoscience, Earth Science

24.1 Introduction

There are nine Olympiad competitions organized in Sri Lanka at the national level by various universities, institutes and societies: Biology, Physics, Astronomy, Information Technology, Mathematics (junior and senior), Statistics, Junior Olympiad, and Earth Science. The Earth Science Olympiad competition, which was initiated in 2009, is the youngest Olympiad in Sri Lanka. Some Olympiads, such as Biology, Physics, Mathematics, and Statistics, are very popular among school students. These subjects are included in the secondary school curriculum, hence their popularity. The syllabi of these competitions are very similar to their school curricula. However, for the Earth Science Olympiad, students must study new concepts not included in their school curriculum. The initial syllabus of the Earth Science Olympiad competition included basic concepts of Geography, basic Geology, Environmental Science, and Astronomy.

24.2 The Education System in Sri Lanka

The Sri Lankan Education system is divided into four main stages, *i.e.* preschool, primary, secondary, and tertiary level (Figure 24.1).

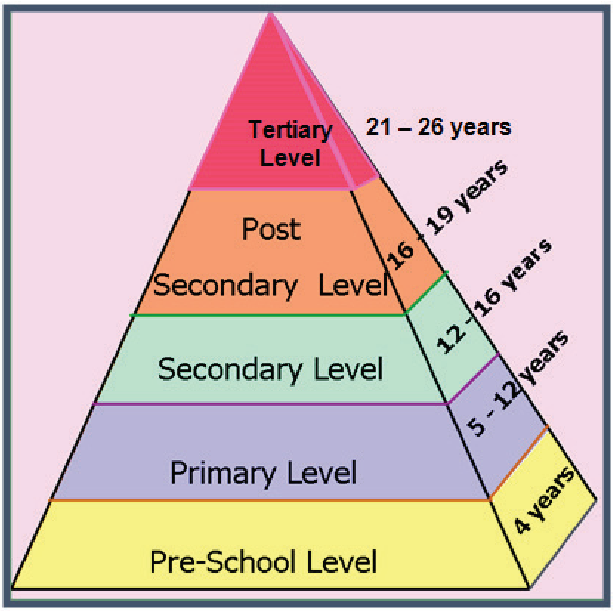

Fig. 24.1 Educational levels in Sri Lanka

The curriculum for preschool mainly focuses on developing students' basic writing, reading, listening, and speaking skills. At primary school, students have the opportunity to master the skills they developed at preschool and be introduced to a few other subjects like Mathematics, Languages, Social Studies, Religion, and Arts. After completing six years of primary education, at about twelve years of age, students are promoted to secondary level education.

In secondary school, students are exposed to subjects like Biology, Physics, Chemistry, Geography, Commerce and Accounting, Agriculture, etc. A few Geology concepts are also introduced at this stage, integrated with some of these subjects. The post-secondary curriculum is very important for students as their tertiary or university level education depends upon the discipline they select from among five disciplines: Biology, Mathematics, Commerce and Accounting, Agriculture, Arts and Languages. After two years of study, students sit competitive examinations and qualified students enter university (Figure 24.2).

According to the education system in Sri Lanka as explained above, students do not have a chance to study Geoscience as a primary subject. This is a key reason students do not continue into Geology as an undergraduate course. Therefore, it is necessary to introduce many geological concepts in secondary school to increase student interest in pursuing Geology at university. This will help produce more future geologists in Sri Lanka. However, compared to other professions like medicine and engineering, there is little demand for geologists in Sri Lanka. This is another reason for students poor motivation to become geologists, favoring higher demand professions instead.

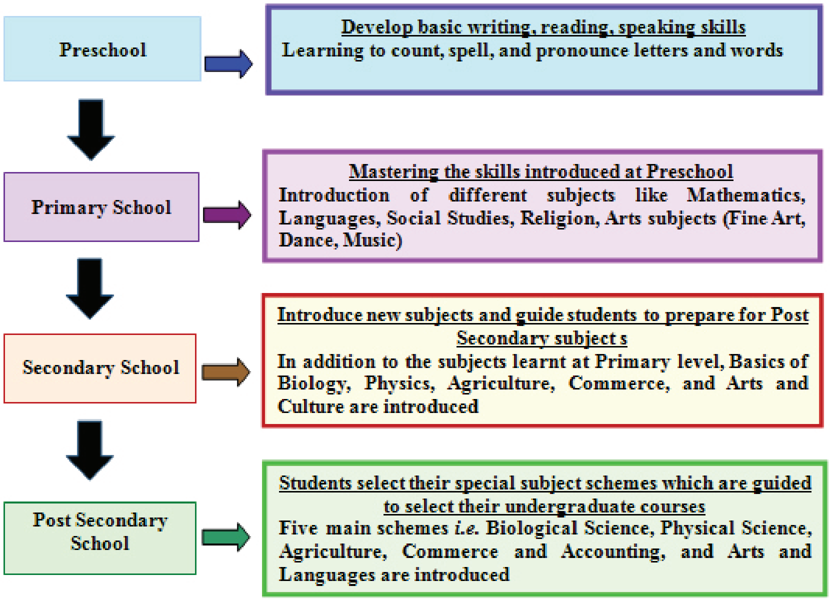

Fig. 24.2 Learning objectives of different levels in the Sri Lankan education system

24.3 Geoscience Education at Secondary School in Sri Lanka

As explained above, Geoscience or Geology is not introduced in primary, secondary or post-secondary school curriculum in Sri Lanka. Therefore, students do not have an opportunity to learn several important concepts, which are very useful and inter-connected with other disciplines. For example, knowing chemical compositions of minerals and rocks is useful when studying similar topics in Chemistry. Similarly, understanding the physical properties of minerals is relevant when studying similar topics in Physics.

School students also have no chance to learn important basic Geoscience concepts useful in their daily life. For example, landslides awareness is critical for those who live in high-risk landslide areas. However, most students do not understand about how landslides occur, what evidence is used to determine landslide occurrence, etc. After the 2004 tsunami, the Sri Lankan government has paid more attention to natural disasters and promoting geoscience education at schools.

The Sri Lankan school curriculum was recently revised. In this revision, a few geoscience topics were included in the 7th to 10th grade syllabus. These topics include minerals, rocks, Earth's interior structure, rock weathering, natural disasters, etc. As students who perform well in secondary education will enter universities to obtain higher degrees, this is an essential stage to promote geoscience and encourage students to pursue Geosciences at university. However, there are still few Geoscience concepts included in pre-secondary school in Sri Lanka. As a result, many students deviate from Geoscience education by university.

24.4 Methods for Promote Geoscience at School Level in Sri Lanka

The Geological Society of Sri Lanka has organized "Earth Science for schools" workshops for school teaches every year. This is the main event utilized to promote Geoscience at school level in Sri Lanka. At these workshops, university lecturers conduct lectures and practical exercises for school teachers. The topics covered in these workshop include: physical geology, minerals, rocks, natural disasters, groundwater, environmental geology, geomorphological processes, etc. Also all teachers are provided geology related teaching materials including minerals and rocks sample boxes to utilize in their schools.

Teachers will share the knowledge gained from these workshops with their students. Therefore, this method is considered useful for promoting Geoscience education among school students. However, if a teacher is unable to transfer the knowledge that he or she gains, students may not have another opportunity to get that knowledge. Other than these workshops, there are no means to directly promote Geoscience at schools. The Ministry of Education and a few other organizations arrange inter-school quizzes, debates, and exhibitions, but these events include little Geoscience content. Compared to these methods, the Earth Science Olympiad is considered an excellent means of promoting Geoscience in schools. Students learn many Geoscience topics by participating in this competition.

24.5 The Sri Lankan National Earth Science Olympiad

The Earth Science Olympiad was introduced in Sri Lanka in 2009. Only 38 students from 21 schools, representing five of twent four districts, participated at the first Sri Lankan National Earth Science Olympiad in 2009. After 2009, the competition syllabus was prepared according to the International Earth Science Olympiad (IESO) syllabus. However, the syllabus comprised only the basics of broad topics like the Geosphere, Environmental Science, the Hydrosphere, Climatology, the Atmosphere, and Astronomy. Each main topic is divided into sub topics as listed in **Table 24.1**.

Compared to the other national Olympiads (*e.g.* biology, physics, chemistry) in Sri Lanka, this was very poor participation. The main reason for this poor participation is the lack of geoscience awareness among school students. The Geological Society of Sri Lanka very clearly identified this barrier to promote geoscience at the school level and found a solution to overcome the situation. Promoting the Sri Lankan National Earth Science Olympiad by organizing workshops and seminars for school teachers is one of the very useful steps they took. At these workshops, the Society introduced the International Earth Science Olympiad syllabus and explained how Sri Lankan students could participate this competition.

Student participation in the National Earth Science Olympiad gradually increased from 2009 to the present (Figure 24.3). There were 68, 112, and 197 students participating in the national competitions in 2010, 2011, and 2012 respectively. In 2013, 282 students participated in the national competition, then increased to 329 in 2014. In 2015, 365 students participated (**Corrige Table 24.2**). After 2013, students represented all 24 districts in the competition.

Table 24.1 Syllabus of the Sri Lankan Earth Science Olympiad competition

Main Topics	Sub Topics
Geosphere	Minerals Rock Cycle Rocks Plate tectonics Physical Geography Geological structures
Hydrosphere	Surface Water Groundwater Sea waves Processes in the water cycle Water quality Tides and currents

Atmosphere and Climatology	Basics and energy of the atmosphere Moisture, clouds, and precipitation Air pressure and motion Weather systems and patterns Climate and climate change Weather forecasts
Astronomy	Sun – interior, sunspots Solar system Terrestrial planets Outer planets, comets and asteroids
Geography	Map interpretation Drainage patterns Geomorphological features

Table 24.2 Students participation in Sri Lankan Earth Science Olympiad competition

Year	Students' participation
2009	38
2010	68
2011	112
2012	197
2013	282
2014	329
2015	365

(from 2009 to 2015)

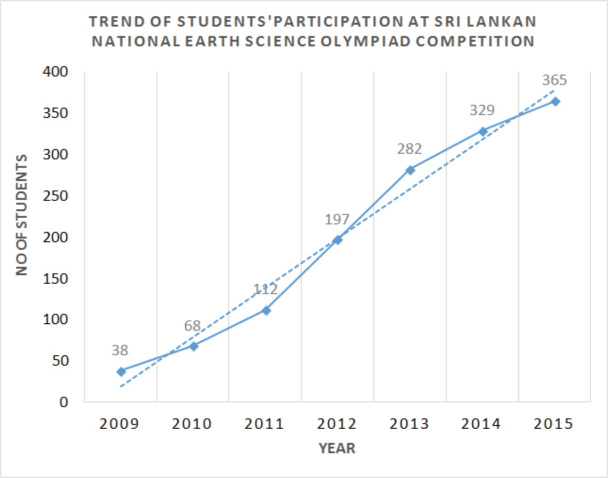

Fig. 24.3 Trend of students' participation at the Sri Lankan National Earth Science Olympiad competition

Students representing three, six, nine, and thirteen districts out of 24 participated in the Sri Lankan National Earth Science Olympiad competitions in 2009, 2010, 2011, and 2012 respectively (Figure 24.4). However, a few districts, like Northern, Southern and Uva provinces, were poorly represented.

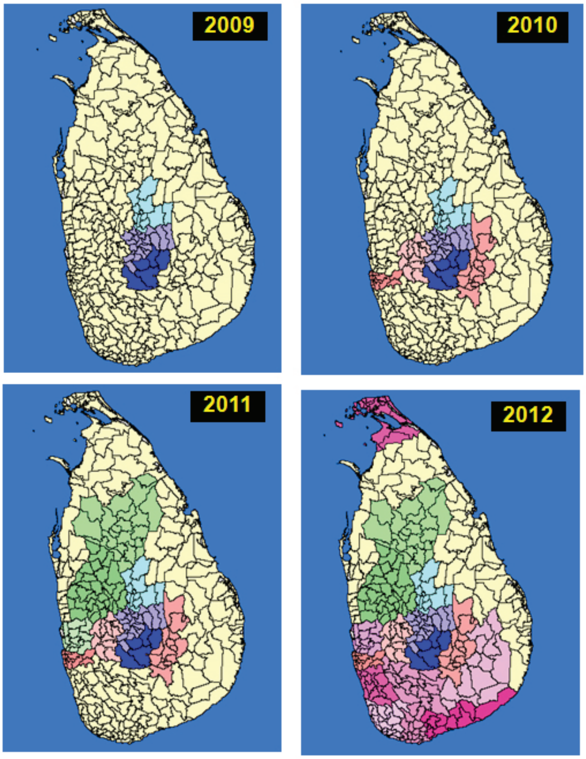

Fig. 24.4 Expansion of Earth Science Olympiad participation in Sri Lanka (by district) from 2009 to 2012

24.6 Sri Lankan Team Participation at the International Earth Science Olympiads

The four best students were selected at the first Sri Lankan Earth Science Olympiad to participate at the 3rd IESO in Taipei, Taiwan 14-22, September, 2009. This was the first time that a Sri Lankan team competed at an IESO. It was a great experience for both students and mentors. After the 3rd IESO, the national competition syllabus was modified to match with that of the IESO. The procedure for selecting national team members was also formalized (see **Figure 24.5**). Since 2009, the Sri Lankan team has participated at four IESOs in Indonesia, Italy, India, and Brazil in 2010, 2011, 2013, and 2015 respectively.

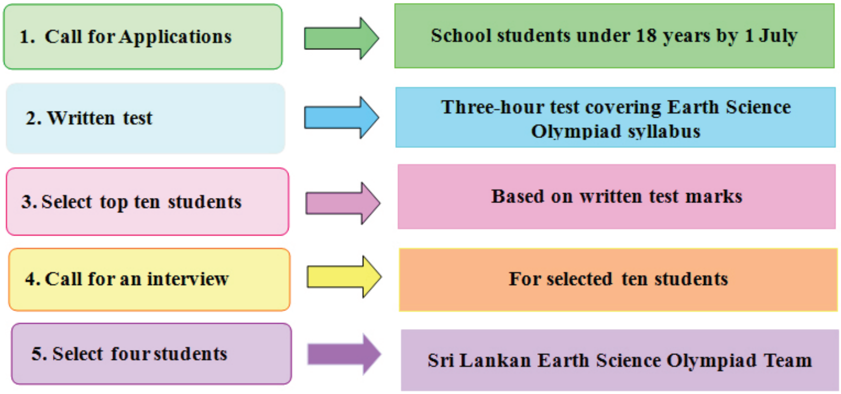

Fig. 24.5 Selection procedure for the Sri Lankan National IESO team

24.7 Conclusion

The diverse methods implemented to promote Geoscience at school in Sri Lanka have been variably successful. Methods requiring little student involvement do not greatly improve awareness of the subject. For example, teacher training workshops and seminars do not directly benefit students if teachers do not transfer the knowledge gained by attending those events to students.

Conversely, preparing students for the Sri Lankan National Earth Science Olympiad allows them to utilize Geoscience related materials (books, websites, etc.) to learn about the topics covered in the competition syllabus. Students must learn this content themselves to prepare for the competition. Therefore, the Earth Science Olympiad competition is better at improving student awareness of Geosciences than other methods in Sri Lankan schools.

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Chapter 25

Geosciences Education in Primary and Secondary Schools in Turkey

Nizamettin Kazancı, Alper Gürbüz, Mübeccel Kazancı

Abstract

Turkey is geographically positioned as a bridge between the continents of Asia, Europe and Africa. The country has very rich and complex geology and geomorphology characterized by the presence of various rock exposures, landscapes, active and inactive volcanic centers, mountain belts, active fault zones, etc. However, geoscience education in a country with such a geological and geographical heritage has become crucial, particularly in the last two decades, after the two devastating earthquakes in the most populated region of Turkey in 1999. From an educational point of view, three periods are identified in the modern educational history of Turkey: a) 1924-1974 – geology courses were compulsory, b) 1975-1998 – geology was elective, c) 1999 to present – geography courses include basic geological topics. Extensive teaching of geological subjects is included within the geography courses, which is compulsory for all classes and branches of all high schools presently, but this is insufficient. Today, the main problem in geoscience education seems to be related to the curricula and the backgrounds of educators in primary and secondary schools.

Keywords: Earth sciences education, geology, geography, primary and secondary schools, Republic of Turkey.

25.1 Introduction

Humans learned early on that the Earth was the only home for living things, and they tried to adapt to it in order to survive. Over time, particularly due to the increasing population, new problems appeared, so they deduced that adaptation to nature was not enough to be safe both as individuals and as societies. For example, increasing impacts of natural hazards (from earthquakes, tsunamis, floods, avalanches, landslides), climate change, pollution and deteriorating environments, shortage of clean water, food and energy, deforestation, desertification, sea-level rise, and greenhouse effects are significant recent problems caused mostly by rapid urbanization. Furthermore, raw materials, typically provided from nature, are vital for urban dwellers but finite. Therefore, humankind had to learn about the Earth and its nature, natural resources, hazards, and particularly sustainability. Fortunately, people have known the significance of such education for a long time, and schools were opened to teach about the Earth. Now, learning about nature is essential for education programs everywhere.

Education in Turkey is governed by a national system, which was established mainly with the 'Integration of Education (*Tevhid-i Tedrisat Kanunu*)' law in 1924. Details of the law greatly changed over time (Özelli, 1974; Akyüz, 1982). It is a government-supervised system designed to produce skillful professionals for society. Private and free public schools work in parallel, however, the majority are public. Presently, compulsory education extends to 12 years. Primary and secondary education is financed by the state and is free of charge in public schools; private schools are also supported by the state. Presently, enrolment of children between the ages of 6 and 18 is nearly 100 percent (Table 1).

Tab 25.1 Population distribution (total 77.6 million) and schooling ratios in Turkey (SGB, 2015).

Agerange	0-14	15-24	25-65	>65
%ofpopulation	25.2	16.5	50.3	8

	Pre-Primary	Primary	Secondary	Highschool	University
Schoolingratio%	53	96	94	79	39
Personnel	33,183	267,171	259,315	249,601	155,000

Stillneedinprimaryandhighschools:121,763

NumberofDepartmentsofGeographyandGeographyTeachinginUniversities	33
NumberofDepartmentofGeologicalEngineeringinUniversities	30
NumberofFacultyofEducationalSciencesinUniversities	87

Although secondary and/or high school education is not mandatory, it is required to progress to university education (Figure 25.1). In 2015, there were 197 universities (state and private) in Turkey. Entrance is regulated by a national examination, after which, high school graduates are assigned to a university according to their performance. Overall, the present Turkish education system (Figure 25.1) highly resembles that of Western countries, as expected from a member of the European Union. The main difference seems to be in the number of students in vocational schools; however, the indicators have rapidly changed (OECD, 2013a, b).

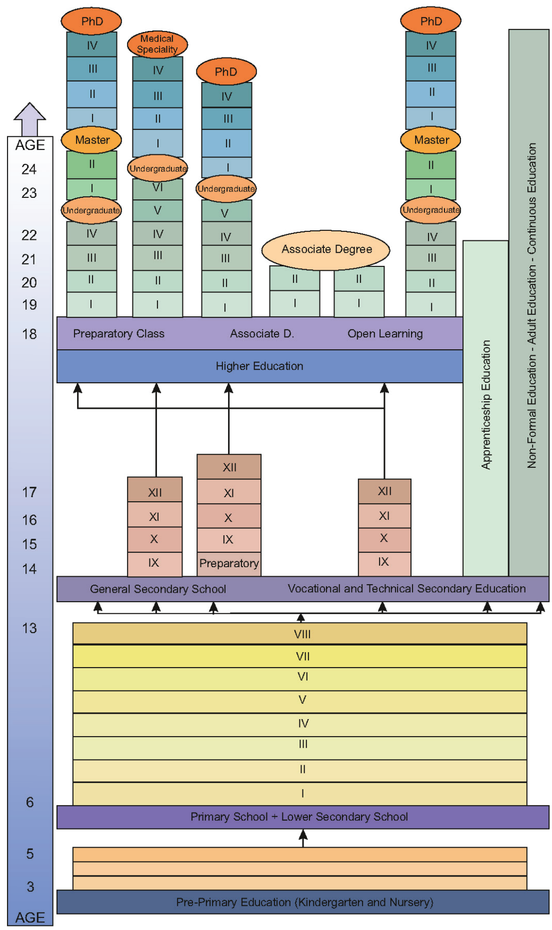

Fig. 25.1 General structure of the Turkish education system. I–VIII and IX–XII grades are in physically separated schools, even though they are both parts of compulsory education(simplifi ed from SGB, 2015)

The Republic of Turkey, which was constructed by a hard war for independence (1919–1922) against the winners of the First World War, needed some new regulations not only in education but in all areas, as the precedent Ottoman Empire had a different state system due to its extremely large area and multi-national structure. One of the basic reforms in the early Republic of Turkey was the integration of laicized education and the establishment of five years compulsory education by a law in 1924 (Akyüz, 1982; MEB, 2015). This law declared that no school could open in Turkey without the permission and agreement of the Ministry of National Education, and all school curricula should be prepared by the ministry. The vocational-technical education institutions that were formerly directed by local governments were put under the responsibility of the ministry. Four years later, in 1928, the alphabet was changed from Arabic to Latin letters. Such a reform was a real necessity for the fresh Republic, as education was very weak and far from building a modern Turkey (Özelli, 1974). For example, in 1923–24, the number of secondary school students was slightly more than 7000, while the population of Turkey was around 13.5 million.

This education reform was successful and helped build modern Turkey. The main structure of the Law in 1924 is still valid, however, before 1997, compulsory primary education was only five years, for ages 7–12, and the rest was optional as secondary schools (middle schools), lasting three years for ages 12–15, and three-year high schools (lyceums) for ages 15–18. Compulsory education increased to eight years in 1997 and to twelve years in 2012. Presently, the schooling ratio within the population of 6–18 year olds is very high, close to 100 percent, and the number of personnel working in the education system is nearly one million (Table 25.1).

The aim of this article is to present the Earth sciences component of Turkey's compulsory education system curriculum. To achieve this goal, some information about formal education is needed first.

25.2 The current formal education system in Turkey

Three institutions, the National Educational Council (NEC), the Ministry of National Education (MNE), and the National Board of Education (NBE), are significant actors in Turkey's formal education system according to the constitution. The NEC is an advisory institution for the ministry that meets whenever the government needs new policy and suggestions. Its members are experts and representatives of different parts of society. The decisions of the 20 NEC meetings since 1921 have strongly affected the Turkish education system. The MNE is the main authority on education, while the NBE is responsible for the curriculum.

As summarized in Figure 25.1, the Turkish formal education system consists of pre-primary education, primary education, secondary education and higher education. The system is bipartite as it is compulsory for primary and secondary schools and optional for pre-primary and higher education. Compulsory education lasts 12 years, divided into three four-year components, providing options to transfer between general and vocational schools. The first eight years (4+4), called first level education (= primary school), are conducted in the same school building, while the last four years (secondary or high school) is taught in separate, stand-alone buildings to avoid problems due to student age differences.

The curricula of all primary and secondary schools are organized by the NBE, a half-independent unit in the MNE. It decides and announces the programs, courses and also the contents of courses regularly. Textbooks are provided to students free of charge by the government in all public schools.

The higher education and/or university system has not been under the direct control of the MNE since 1960. It is now coordinated by the Board of Higher Education, members of which are nominated by the head of the Turkish Republic. The following paragraphs briefly introduce the different school levels, except for higher education.

25.2.1 Pre-primary education

Pre-primary schools in Turkey are an optional system for education of children between 36–72-months old who are under the age of compulsory primary education. Although it is optional, participation is rapidly increasing due to urbanization. The relevant schools are generally independent nurseries, some of which are opened as nursery classes and practical classes within formal schools, when suitable physical capacity is available. Services related to pre-primary education are given by nurseries and kindergartens in practical classes operated first and foremost by the MNE. Additionally, schools for this level of education are encouraged by MNE as day-centers, nursery schools, day care houses, child care houses, and child care institutions. Presently, the schooling ratio in this level of education is about 53 percent (Table 25.1). The goal is to reach 100 percent for children of this age before the 100th anniversary of the republic in 2023 (SGB, 2015).

25.2.2 Primary education

In Turkey's formal merit system, primary education is 4+4 years, covering the education of children between 6-14 years old. It is compulsory for all citizens, boys and girls, and provided free of charge in public schools. Private schools are present and even encouraged by the state.

Core courses of the first, second and third grades are mainly Turkish, mathematics, life science, and foreign language, however the latter can change from school to school. The course 'life science' is replaced by the course 'science and social studies' in fourth grade. Foreign language teaching is relatively strong in private schools, with English most commonly taught, while some schools teach German, French or Spanish instead of English. Some private schools teach two foreign languages at the same time.

In the sixth, seventh and eighth grades, Turkish, math, foreign language, sciences, and social sciences are the five main courses, however 'social sciences' is replaced by the courses history and citizenship in eighth grade.

As mentioned above, primary education institutions are schools that provide eight years of uninterrupted education. Daily lessons are provided all day in some schools; however, two education sessions (morning and afternoon) are conducted each day in some schools, due to capacity shortages. There are typically six classes per day, lasting 45 minutes, with 10-minute breaks. The places and units of the schools are under the control of the MNE. At the end of the eight years, graduates receive a primary education diploma.

25.2.3 Secondary education

Turkish secondary education includes all general, vocational and technical schools that provide four years of education. The last year (12th grade), however, is generally preparatory for university and/or working life. Some schools and also types of schools in secondary education are preferred (Tables 25.2, 25.3). Therefore, a relative level of success is needed to enter a preferred school. To evaluate student success, the MNE organizes a common, national exam in the second semester of 8th grade. Sometimes private schools have different exams, and other times they only look at school grades. Secondary education aims to give students a good level of common knowledge and prepare them for higher education, a vocation, life, and business, in line with their interests, skills and abilities.

Secondary schools cover the education of youth between 15–18 years old for at least four years after primary education. General secondary education includes high schools, foreign language teaching high schools, Anatolian high schools, science high schools, Anatolian teacher training high schools, and Anatolian fine arts high schools (Table 25.2). In Anatolian high schools and private high schools, the daily programs are typically longer, up to eight classes each day, than those of public high schools.

Tab. 25.2 Types of secondary schools and hours of geography course in their programs (SGB, 2015). Numbers in parenthesis show total hours for all courses.

Type of high school	Number of Compulsory (C) courses	Number of Elective (E) courses	Weekly hours of Geography and all courses							
			9th grade		**10th grade**		**11th grade**		**12th grade**	
			C	**E**	**C**	**E**	**C**	**E**	**C**	**E**
General	17	16	2 (30)	- (7)	2 (20)	- (15)	- (20)	2 (15)	- (17)	2 (18)
Anatolian	18	16	2 (35)	-	2 (19)	- (16)	- (20)	2 (15)	- (17)	2 (18)
Science	18	7	2 (39)	-	2 (37)	-	- (36)	-	- (17)	- (18)
Social sciences	26	-	2 (40)	-	4 (40)	-	3 (40)	-	4 (40)	-
Arts	28	4	2 (40)	-	2 (35)	-	- (35)	-	- (35)	-
Sport	34	8	2 (40)	-	2 (35)	-	- (35)	-	- (35)	-
Music	32	4	2 (40)	-	2 (35)	-	- (35)	-	- (35)	-
Teacher's training	23	15	2 (34)	- (5)	2 (23)	- (15)	- (22)	- (16)	- (19)	- (19)

Vocational and technical secondary education involves schools that train students for careers in business and other professional areas (MEB, 2015, SGB, 2015). It includes specified technical education schools for boys and girls, *i.e.* trade and tourism schools, religious education schools, multi-program high schools, special education schools, private education schools, and health education schools (SGB, 2015).

The 9th-grade course program is similar more or less in all secondary schools. Courses are about 36–37 hours per week, including some electives (Tables 25.2, 25.3). The core classes are the Turkish language, Turkish literature, mathematics, physics, chemistry, biology, geometry, history, geography, religion and ethics, physical education, and foreign language (Table 25.3).

From 10th grade on, programs are highly differentiated in secondary schools. Students of general schools choose one of four branches: *Turkish* *language–mathematics*, *science*, *social sciences,* or *foreign languages*. In vocational high schools, there are no branches, while only the *science* branch is offered in science high schools. On the other hand, some schools offer elective courses instead of branches. For 10th, 11th and 12th grades, the compulsory courses are: Turkish language, Turkish literature, History of the Republic, and religion and ethics. In addition to these courses, students attend classes in mathematics, geometry, statistics, physics, biology, chemistry, geography, philosophy, psychology, sociology, economics, logic, arts and music, traffic and health, computer science, physical education, and first and second foreign language, depending on the chosen branch and/or the high school. The number and weekly hours of elective courses also changes in different schools (Tables 25.2, 25.3). Branches help and provide advantages to students preparing for university in a variety of fields, *i.e.* international relations, law, education, psychology, economics, business management, and similar fields require high marks in Turkish language and mathematics, while medicine, computer science and other science-related professions require good marks in science. However, geography has always remained in the social sciences branch of the Turkish education system (Şahin, 2001).

Tab. 25.3 Weekly program of a general high school in 2015 (http://ttkb.meb.gov.tr/). Note, nearly all of the courses are compulsory for 9th grade. Hours of a geography course may reach up to 14 if desired.

Course category	Courses	9th grade	10th grade	11th grade	12th grade
COMMON and COMPULSORY	Turkish and composition	2	2	2	2
	Turkish literature	3	3	3	3
	Religious culture and ethics	1	1	1	1
	History	2	2	-	-
	History of Turkish Republic	-	-	2	-
	Geography	2	2	-	-
	Mathematics	4	-	-	-
	Geometry	2	-	-	-
	Physics	2	-	-	-
	Chemistry	2	-	-	-
	Biology	2	-	-	-
	Introduction to Health	1	-	-	-
	Philosophy	-	-	2	-
	Foreign language	3	2	2	2
	Physical education	2	2	2	2
	Visual arts /music	1	1	1	1
	Traffics and first aid	-	-	-	1
Total compulsory courses hours		29	15	15	12

Course category	Courses	9^{th} grade	10^{th} grade	11^{th} grade	12^{th} grade
E	Turkish and composition	-	2	2/3	2/3
	Turkish literature	-	1	1	1
L	Mathematics	-	2/4	2/4	2/4
	Geometry	-	1/2	2/3	1/2
E	Physics	-	2/3	2/4	2/3
	Chemistry	-	2/3	2/4	2/4
C	Biology	-	2/3	2/4	2/3
	History	-	2	2/4	-
T	Modern Turkish and World history	-	-	-	2/4
I	Geography	-	2	2/4	2/4
	Psychology	-	2	-	-
V	Sociology	-	-	2	-
	Logic	-	-	-	2
E	Foreign language	-	2/4	2/4	2/4
	Second foreign language	-	2/4	2/4	2/4
S	Other elective courses	7	2	1	2
Total elective courses hours		7	14	14	17
Consultancy and Guiding		1	1	1	1
Total weekly hours		37	30	30	30

25.3 Earth Sciences Education in Primary and Secondary Schools

The Turkish curricula for students 6–18 years old includes a good deal of basic information about the environment, nature, ecology, climate, wildlife, and the formation and evolution of the Earth, rocks, minerals, fossils, etc. This information has been distributed in courses of 'Life science' for 2^{nd} and 3^{th} grades, 'Science and social studies' for 4^{th}–8^{th} and Geography for 9^{th}–12^{th} grades. In fact, information about the solid Earth and cosmos was taught in the Turkish education system since the Ottomans, with courses called '*Arziyat*' (Earth science) and '*Kozmografya*' (Cosmography), although they were not well designed for students' abilities (Taş, 2005; İncekara, 2007; Figure 25.2). After introducing the new law in 1924, '*Arziyat*' and '*Kozmografya*' were replaced by '*Geology*' and '*Astronomy*', respectively, which continued as two main courses in secondary schools until 1974 (archive of the bulletin '*Tebligler Dergisi*'; http://tebligler.meb.gov.tr/). From then until 2012, the Geology course remained as an elective in the science branch of secondary schools when it was removed completely from the curriculum (Figure 25.2). However, Geology course content was partly added into Geography from 9th to 12th grades (TTKB, 2011). According to a recent announcement on the NBE website (http://ttkb.meb.gov.tr/; last access March 18, 2016), Earth sciences lectures in the current Geography program will decrease significantly after 2016 to allow more time for regions, cultures and population, based on the NEC's advice.

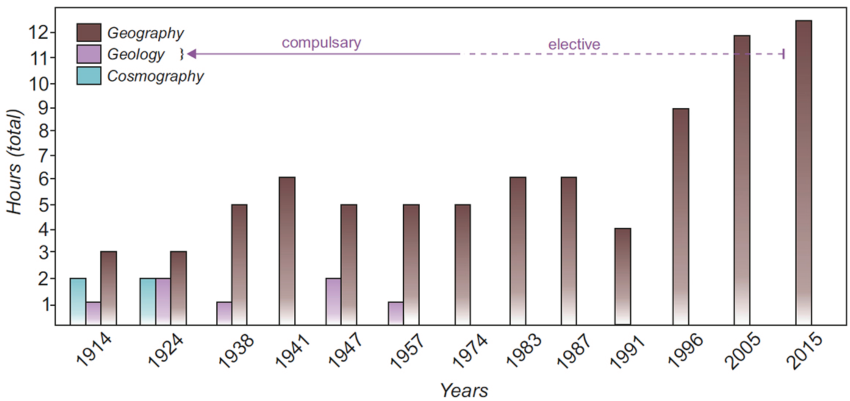

Fig. 25.2 Geosciences related courses in Turkey. Geology was an elective course between 1974 and 2012 only for the 12th-grade science branches, while geography was always compulsory for the Anatolian and general high schools. Total hours in the graph represent the maximum hours in the social sciences branches of these schools. For other branches, the compulsory geography course hours are less as 4 hours, but they can be increased to 8 hours with elective courses. Data are from the formal course programs that were published by the NBE.

In the meantime, there is no doubt that teachers and teacher-training are always primary factors in education quality. In Turkey, the teacher training conducted by the MNE according to employment-based policy was completely left to the universities in 1982. The Council of Higher Education re-established the teacher training system for education faculties in the 1998-1999 academic year. As a result, primary and secondary school teachers started to be trained only in university Educational Sciences faculty programs, whereas high school (branch) teachers started to be trained to the Master's degree level (Bilir, 2011). This reestablishment was not a positive development for teaching Earth sciences because geology was an engineering program within Science or Engineering faculties. The solution was to enlarge geography education within the Educational Sciences faculties programs, including some Earth science topics. Presently, while all the Earth science topics are taught by geography teachers in secondary schools, similar content in 3th–8th grades are taught by general classroom teachers.

25.3.1 Earth Science Topics in the Curricula

Here, we summarize the general Earth science topics in the programs of different grades. It is however, sometimes difficult to determine which topics belong to geography, ecology or geology. It is noteworthy that the topic's teaching times determined by the NBE are not less than 1–2 hours/week in a semester. The courses and their relevant topics are as follows in the current curricula (TTKB, 2015).

In 3rd-grade Life Science: description of continents and oceans on the map; hydrological cycle; movements of the Earth

In 4th-grade Social Sciences: atmosphere and atmospheric events; natural disasters and preparedness for hazards

In 5th-grade Social Sciences: relations of natural disasters and regional geographic properties; natural hazards and causes

In 6th-grade Science and Technology: maps and scales; oceans and continents; climate and habitats; climatic zones of Turkey; climate and geomorphology; controlling factors of settlements

In 9th-grade Geography: maps and geomorphology; contour lines; tectonics and tectonism; Geological times and events; control of endogenic forces on morphology; and control of exogenic forces on landforms

In 10th-grade Geography: rocks and their characteristics; relations of rocks and landscapes; groundwater and water sources; soil and soil types; natural disasters and hazards; preparedness for hazards

In 11th-grade Geography: factors on the formation of biodiversity; elements of ecosystems; water and water ecosystem; ore deposits; natural energy sources

In 12th grade Geography: extreme conditions of natural events; interactions of natural and anthropogenic processes; predicting natural transformations; management of natural environments; management of natural resources; conservation of geological heritages.

25.3.2 Assessment and Evaluation

The results of Earth science education and its effects on citizen's daily lives are not very clear in Turkey as there is no reliable assessment to make a satisfying evaluation. The only data could be weekly programs and their coverage (Tables 25.2, 25.3). From the Earth sciences point of view, three terms in Turkey's modern education history are identified; a) 1924–1974, a geology course was compulsory, b) 1975–1998, geology was elective, c) 1999 to present, geography courses include geology topics (Figure 25.2). Surprisingly, we notice geology-related subjects were taught extensively for the last two decades as the geography course was compulsory for all classes and branches of all high schools. As a result, presently students in primary and secondary education are relatively much more familiar with Earth science topics. In this period, the problems are mainly dependent on teacher training and qualification.

Earlier, geology education was good, as teachers were well educated in geology, but the course was only compulsory for the 12th grade science branches. Earth sciences education appeared very weak in 1974–1998 as it was elective only for science branches of a few types of high schools in 12th grade (Tables 25.2, 25.3). This meant that limited students could take the course, even if there were enough teachers. Moreover, the course needed to be elected by at least ten students to be offered, however, the absence of Earth science questions on the joint exam for university entrance negatively effects the elective geology course.

The Scientific and Technological Research Council of Turkey (TÜBİTAK) supports and encourages the attendance of students at the International Science Olympiads. Unfortunately, there is not yet such an organization for the Earth sciences. However, geology and/or Earth sciences topics are favorites among secondary school students in the national project competition of the TÜBİTAK.

25.4 Concluding remarks

Turkey looks like a bridge between the continents of Asia, Europe and Africa. Therefore, it has very complex geology, characterized by the presence of various rocks and fossils belonging to these continents. In addition to its various landforms, active and inactive volcanic centers, mountain belts, and seismic zones, the country has a long-lived cultural heritage. Hence, its spatial position contains immense geoscientific and cultural values for discovery by inhabitants, at least to avoid natural hazards. However, the university geology and geography departments are not now favored by young people due to unemployment. On the other hand, local authorities and municipalities are now slowly becoming aware of the geotourism potential of natural formations. Mountaineering, trekking, alpinism, and cave tourism are increasing rapidly in Turkey. Moreover, society has learned the concepts of geoparks, geoheritage and geoconservation. In conclusion, the authors hope that clear geoscience education curricula will formally support this geological richness and direct social development in the near future.

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Chapter 26

Earth Science Education in the United States

Mary E. Dowse and Sharon Locke

Abstract

In the United States, the federal government provides guidance to develop standards, but it is the responsibility of each state to establish curriculum and standards for teacher preparation and licensure. National Science Education Standards, first published in 1995 and updated as the Next Generation Science Standards in 2014, are guidelines and models for science standards adopted in each state. Earth and space science have a prominent place in the science standards as one of the three topic areas with physical science and life science incorporated into the standards. There are at present no national exams for students in the United States. Regulations for teacher licensure are also enacted at the state level, hence there is considerable variation from state to state in teacher requirements.

Keywords: United States, Earth Science Education, Next Generation Science Standards, Teacher Preparation

26.1 Educational System in the United States

The responsibility for education in public schools, those funded by the government, in the United States is spread between the federal, state and local authorities. The federal government provides policy guidance, assistance in developing instructional material, and best pedagogic practices. On average, the federal government provides 9.6% of the funding for schools (National Education Association, 2015). The states take the lead in establishing curriculum, setting standards for teacher licensure, requirements for graduation, and in some cases, approving instructional materials (Table 26.1). The states provide, on average, 46.4% of the funding for schools (National Education Association, 2015). Local school districts, clusters of schools in cities and other areas, establish curriculum following state guidelines, adding additional materials as decided. Local revenue provides on average 44.0% of the funding for public schools.

Educational policies are not uniform across the United States but vary as each state establishes its own policy. In general, most states mandate that students from the age of 5 or 6 to age 16 must be enrolled in school. The transition from elementary school to middle school and middle school to high school varies from one school district to another.

Tab. 26.1 Average age ranges and educational terminology in the United States

Age (years)	Type of School	School Years	Comparison to UK
5-10	Elementary/Primary School	Kindergarten Grades 1-5 in most school systems. May range from 1-4 to 1-8 in other systems.	Kindergarten is equivalent to year 1 in England. Grades K-5 are equivalent to school years 1-6 in England.
11-13	Middle School	Grades 6-8 in most school systems. May range from 5-9 in other systems.	Equivalent to lower secondary, school years 7-9 in England.
14-18	High School	Grades 9-12. Maybe grades 10-12.	Equivalent to upper secondary and sixth form or college. School years 10-13 in England.
18 or 19+	University	4-year undergraduate	College/University

Traditionally, most school systems in the United States offered Earth science to students in middle school or first year high school students. Physical Science, a combination of physics and chemistry, and Earth science were often perceived as the sciences for slower students as the 'better' students took biology, usually followed by chemistry and then physics. A few schools with committed and dedicated Earth science teachers do offer an advanced Earth science course to students in grades 11 or 12 that is viewed as a capstone course.

26.2 National Science Education Standards

One of the roles of the federal government is to establish standards and encourage accountability, but the standards cannot in any way be regarded as a national curriculum. The standards provide guidance to the states in developing and implementing standards. Thus, standards may vary significantly from state to state. According to a 2012 report, The State of State

Science Standards 2012 (Lerner, et al., 2012), many standards written by the states are weak. According to the report the four most prominent issues with state standards are: (1) attempts to undermine the teaching of evolution; (2) standards that are frequently vague; (3) poor integration of scientific inquiry; and (4) the disconnect between math and science in standards.

26.3 Developing the Standards

Following Russia's launch of the Sputnik satellite in 1957, the United States passed the National Defense Education Act (NDEA) in 1958. The NDEA was intended to increase the capacity of the United States in science and technology using a broad range of strategies. One of the components of the NDEA was the development of curriculum materials. The Earth Science Curriculum Project (ESCP) was sponsored by the American Geological Institute (AGI, now the American Geoscience Institute) and funded by the National Science Foundation. The ESCP produced a textbook for 9th grade students, Investigating the Earth (Harris, 1976). The emphasis was an investigative and integrative approach to Earth Science.

In 1995, the National Research Council published the National Science Education Standards (NSES) in response to reports such as A Nation at Risk (National Commission on Excellence in Education, 1983) that called attention to the fact that schools in the United States were failing to adequately prepare students for the future.

The NSES clearly established the importance of Earth and Space Science as a content area for students. The Science Content Standards place physical science, life science and Earth and space science on the same level. These Content Standards were developed for three levels: Grades K-4, Grades 5-8, and Grades 9-12. The standards also highlight unifying concepts and processes and teaching science as inquiry.

In 2012, the National Research Council published A Framework for K-12 Science Standards. The framework highlighted the scientific ideas and practices that all students should know by the end of high school (Grade 12) and was the basis for the Next Generation Science Standards (NGSS Lead States, 2013). Twenty-six states, the National Science Teachers Association, and the American Association for the Advancement of Science worked together to write the updated standards. The standards integrate findings from recent research on how people learn, and therefore offer a vision for learning science grounded in cognitive science.

The NGSS are arranged in three dimensions: cross-cutting concepts, disciplinary core ideas, and scientific and engineering practices. The standards are designed to show how the concepts and practices relate to the core ideas. Cross-cutting concepts highlight the connections between all of the sciences by considering seven topics: patterns; cause and effect; scale, proportion and quantity; systems and system models; energy and matter; structure and function; stability and change. Likewise eight scientific and engineering practices highlight how scientists study the natural world: 1) asking questions and defining problems, 2) developing and using models, 3) planning and conducting investigations, 4) analyzing and interpreting data, 5) using mathematics and computational thinking, 6) constructing explanations and designing solutions, 7) engaging in argument from evidence, and 8) obtaining, evaluating, and communicating information. The intent is that students should engage in all eight practices at every grade level.

The standards include performance expectations of what students should know and be able to in grades K-2, 3-5, 6-8, and 9-12. The expectations are designed to show a progression of increasing sophistication as student moves through school.

26.4 Earth Science in the Next Generation Science Standards

The NGSS (NGSS Lead States, 2013) are arranged into three disciplinary content areas: Physical Science, Life Science, and Earth and Space Science. The content standards for Earth and Space Science is grouped into three themes or threads:

- Earth's place in the universe;
- Earth's systems and;
- Earth and human activity.

At the elementary level, standards and storylines are provided at each grade level. Table 26.2 shows the core ideas in Earth Science for students at the 5th grade level. Links to the cross-cutting concepts and science and engineering practices are omitted here, as are links to other locations where each of the topics is discussed in the standards.

Tab. 26.2 Grade 5 Disciplinary Core Ideas

ESS2.A: Earth Materials and Systems
• Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather.
ESS2.C: The Roles of Water in Earth's Surface Processes
• Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere.
ESS3.C: Human Impacts on Earth Systems
• Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.

Table 26.3 shows the disciplinary core ideas for Earth Science for students at the middle school level. The standards for space science are not shown. The links to the cross-cutting concepts and science and engineering practices are omitted here, as are links to other locations where each of the topics is discussed in the standards.

Tab. 26.3 Middle School (Grades 6-8): Disciplinary Core ideas

ESS1.C: The History of Planet Earth
• Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches.
ESS2.A: Earth's Materials and Systems
• All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
• The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.
ESS2.B: Plate Tectonics and Large-Scale System Interactions
• Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.
ESS2.C: The Roles of Water in Earth's Surface Processes
• Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
• The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.
• Global movements of water and its changes in form are propelled by sunlight and gravity.

• Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. • Water's movements, both on the land and underground, cause weathering and erosion, which change the land's surface features and create underground formations. ESS2.D: Weather and Climate • Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. • Because these patterns are so complex, weather can only be predicted probabilistically. • The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

Table 26.4 shows the disciplinary core ideas for Earth Science for students at the high school level. The standards for space science are not shown. The links to the cross-cutting concepts and science and engineering practices are omitted here, as are links to other locations where each of the topics is discussed in the standards.

Tab. 26.4 High School (Grades 9-12): Disciplinary Core ideas

ESS1.B: Earth and the Solar System • Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. ESS1.C: The History of Planet Earth • Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. • Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. ESS2.A: Earth Materials and Systems • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. • Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. • The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. ESS2.B: Plate Tectonics and Large-Scale System Interactions • Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. ESS2.C: The Roles of Water in Earth's Surface Processes • The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. ESS2.D: Weather and Climate

• The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.
• Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.
• Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.
• Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere.
ESS2.E Biogeology
• The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it.
ESS3.A: Natural Resources
• Resource availability has guided the development of human society.
• All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.
SS3.B: Natural Hazards
• Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.
ESS3.C: Human Impacts on Earth Systems
• The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.
• Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.
ESS3.D: Global Climate Change
• Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.
• Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

It is important to reiterate that in the United States the proposed standards are not mandated but serve as guides for the states, who have the responsibility for adopting standards. There continue to be significant political debates in the United States about standards, not only in science but in other areas as well. Objections to standards are about content in some cases and also reflect concerns about maintaining local control over education.

26.5 National Tests

In the United States there are presently no national exams in science for students graduating from high school. The Federal government mandates annual testing of students in language arts and math, but leaves the design, implementation and evaluation of the tests to the individual states.

Additionally, the National Assessment for Educational Progress (NAEP) is administered approximately every four years to small samples of students in grades 4, 8, and 12. Results and analysis of the NAEP exams are reported in the The Nation's Report Card (National Center for Educational Statistics, 2016). The most recently reported results in science are for 8^{th} grade students in 2011. Overall, 32 percent of students were considered proficient in science. The assessment does include Earth and space Science. In order to be considered proficient in Earth and space science students

> "should be able to explain how gravity accounts for the visible patterns of motion of the Earth, Sun, and Moon; explain how fossils and rock formations are used for relative dating; use models of Earth's interior to explain lithospheric plate movement; explain the formation of Earth materials using the properties of rocks and soils; identify recurring patterns of weather phenomena; and predict surface and groundwater movement in different regions of the world." (National Center for Educational Statistics, 2011).

26.6 Teacher Education and Certification

In the United States the public school system is not a single system, but more than 50 different systems. Each state ultimately holds the responsibility for establishing standards for education, teacher training, and certification.

Teachers are certified at the state level and the requirements for teacher training and certification vary from state to state. Although some states will accept certification from other states, there is no nationally accepted certificate. The qualifications for each state can be viewed at the web site www.Teach.org. Most states require a bachelor's degree at a minimum and completion of a teacher preparation program at either the bachelor's level, master's level or through an alternative licensure program. Generally states require teachers to pass a general teaching exam and may require content-area exams as well.

State requirements for content education vary significantly and vary between institutions of higher education that offer teacher preparation. The duration and depth of Earth science content varies significantly. Some elementary pre-service teachers may take a semester-long (15 week) general Earth science course or a specialized Earth science course designed for teachers. Others may receive almost no instruction in Earth science.

Secondary Earth science teachers may major in geology or a closely related science in addition to their teacher preparation courses. The All Purpose Science Teacher report from the National Council on Teacher Quality (2011) notes that only 11 states require certification in a specific subject. All others certify teachers in general science or in multiple disciplines. The teachers are expected to pass a general knowledge exam in science, but those exams do not ensure in-depth knowledge in any one discipline.

An increasing number of institutions are offering Master of Arts in Teaching in Earth Science. Increasingly these programs are offered online with a summer residence to conduct field work. Many states also offer professionals with a bachelor's degree in science the opportunity to pursue an alternative licensure which may include teaching while pursuing certification.

26.7 Professional Development for In-Service Teachers

Ongoing teacher professional development is a way for teachers to continue to deepen their content knowledge, visit unique field sites, learn new teaching strategies, and fulfill their continuing education requirements. As states move to adopt the NGSS, teachers, particularly at the elementary level, may need additional training and support to implement a curriculum consistent with the three dimensions: core ideas, science and engineering practices, and cross-cutting concepts.

The U.S. Department of Education provides funding administered by the states through the Math Science Partnerships program for the development of high-quality teacher professional development programs. Universities, professional organizations, science museums, and nature centers are increasingly offering a wide-range of programs for in-service teachers. These vary in format, length and cost.

26.8 Conclusion

The government-funded public school system in the United States in an amalgamation of more than 50 different systems. Each state is ultimately responsible to establish education standards, teacher training, and certification processes. The new science standards provide a strong, research-based guiding framework for Earth science education, but ultimately states decide whether to adopt the standards or create their own. Early evidence suggests that states developing their own science standards are drawing heavily on the NGSS. Universities have moved relatively quickly to incorporate NGSS into teacher certification programs, but in-service professional development for the NGSS Earth science standards needs further development. The National Science Teachers Association (www.nsta.org) is an early leader providing online resources to support teachers implementing the three-dimensional approach to science learning.

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Chapter 27

Earth science education: the case of secondary school education, general of Venezuela

Adriana Mercedes Camejo Aviles

Abstract

Incorporating Earth Sciences studies into the Venezuelan secondary education curriculum represented and represents an important tool for the student population to gain a better understanding of natural phenomena throughout geologic history and how it has influenced the development of life on the planet. This work presents an overview of the Venezuelan educational system structure, consisting of subsystems, levels, and modalities, according to the stages of human development. Similarly, it details the professional Geosciences education profile, how the Earth Science discipline is addressed in the national secondary education system, and finally exposes some weaknesses with suggestions to improve Earth Sciences teaching nationally.

Keywords: science education, Earth Sciences, General Secondary Education, Venezuela

27.1 Introduction

Earth Science education in Venezuela is an important tool for the student population to better understand the natural phenomena that have shaped the development of life on the planet throughout geologic history.

Due to its geographic location and its geomorphic diversity, Venezuela is prone to natural events such as earthquakes, landslides, floods, and tsunamis, among others. Therefore, it is of the utmost importance that teachers trained in this area contribute to the formation of a culture of integrated risk management within all levels of secondary education, focusing on the fundamental use of appropriate scientific language. The primary objective is that the population possesses the necessary tools to manage high-risk situations that may occur before, during and after an event, and translating this into a well informed citizenry.

Additionally, Venezuela has one of the largest oil reserves in the world, plus important mineral deposits, so it is essential to create a greater sense of connection to the great oil and mining wealth that the national territory possesses, driving its main economic activities. The contribution of Earth Science education is fundamentally focused on students' understanding of how these mineral resources are formed and exploited, as well as knowing what tools facilitate ecosystem conservation and repair from the affects of these activities.

This document aims to provide a general overview of how the Venezuelan educational system is structured, the profile of the Earth Science professor, and finally, how the Earth Sciences discipline is addressed in the national secondary education system.

27.2 Venezuelan educational system

The Venezuelan Educational System has a set of laws and fundamental rules that govern its operation. Within these laws, the most relevant at the national level are: the Constitution of the Bolivarian Republic of Venezuela (CRBV) of 1961 and reformed in 1999, and the Organic Law of Education (LOE) reformed in 2009; the Rule of the Organic Law of Education, applied to Basic Education levels, the Teaching Profession Regulation Exercise in 2000; and the Organic Law for the Protection of Children and Adolescents of 2007, among others. This set of laws also governs private education nationally.

Education is considered within Articles 102 and 103 of the Constitution of the Bolivarian Republic of Venezuela as a human right and a fundamental social duty, as well as being democratic, free and mandatory for all Venezuelan citizens. Similarly, Article 4 of the Organic Law of Education (2009) states that education is the central axis in the creation, transmission and reproduction of the various manifestations and cultural values, inventions, expressions, representations and own characteristics to appreciate, assume and transform reality.

The subsystem of Venezuelan secondary education has undergone a series of iterative transformative processes, generating significant changes, according to a retrospective study on design and curricular changes from 1971 to 2013 (Andrés, et al., 2014). They examine the curriculum reform process tackled from the consolidation of representative democracy to the implementation of the Bolivarian High Schools and texts of the Ministry of the Popular Power for Education (MPPE).

In 1980, the new Organic Law on Education (LOE) was approved, wherein the educational system became structured by levels and modalities. Primary Education was subdivided into three levels: 1st to 3rd grade, 4th to 6th grade, and 7th to 9th year, plus Diversified and Professional Education, with durations of two to three years, respectively. The National Center for the Improvement of the Teaching of Sciences (CENAMEC) was also created. Starting in 1999, political and social changes in the country resulted in new modifications in the national education system, consummated in the 2009 Organic Law of Education reform.

According to Article 24 of the LOE (2009), the Educational System is made up of subsystems, levels, and modalities, according to the stages of human development (see Table 27.1).

Tab. 27.1 Venezuelan Educational System Structure

Subsystem	Levels	Modalities	Duration	Age
	Initial education	Maternal stage	5 years	0 and 5 years
Basic Education		Preschool stage		
	Primary education	First to sixth grade	5 years	6 to 12 years
	General middle education	First to fifth year	5 years	12-18 years
	Technical secondary education	First to sixth year		12-18 years
University Education	Undergraduate	Bachelor's degree Technicians	5 years 3 years	
	Postgraduate			

The modalities of the education system, set out in Article No. 26 of the LOE, represent variants available for individuals who, due to their characteristics and specific conditions of their integral development, culture, ethnicity, linguistic abilities, etc., require curricular adaptations permanently or temporarily to respond to the demands of different educational levels. The educational modalities are: special education, youth education, adult education, border education, rural education, arts education, military education, intercultural education, and bilingual intercultural education.

In the Venezuelan Educational System, students attend educational centers for 200 working days, beginning in September of each year, according to Article 49 of the Organic Law of Education. The University education subsystem is governed by special regulations.

27.3 The Professor of Earth Sciences: Vocational Training

The Pedagogical Experimental University Liberator (UPEL), is the main university responsible for teacher training in Venezuela. One area of teacher training offered provides specialization in Earth Sciences. Another instituion, the University of the Andes (ULA), offers a degree in Education, Geography and Earth Sciences. Although these two national institutions have different core directives, they are the primary centers for training Earth Sciences specialist educators. Additionally, Geologists, Geographers and related specialists, provided they have a pedagogical component completed or in development, can teach classrooms in the subsystem of general and higher education.

Of the eight centers of the UPEL, only the Pedagogical Institute of Caracas (IPC) and the Pedagogical Institute of Maracay (IPM) have Earth Sciences departments, through which they train teachers specialized in the areas of Geosciences and Comprehensive Risk Management. The teacher training plan in these two institutes is approved, and comprises four components, namely: Specialized Training, with a total of 21 disciplinary courses (see Table 27.2); Pedagogical, with 15 courses; General Training, with a total of nine courses; and finally the Teaching Practice, with four phases of professional practice developed in general secondary education classrooms.

Table 27.2 The specialized Earth Sciences Study Plan training component from UPEL. Taken from the 1997 curriculum design

	Specialized Training Components (obligatory courses)
Area	**Courses**
Mathematics	Introduction to Calculation
	Calculation
Basic physics	Basic Physics for Earth Sciences
General Chemistry	Fundamentals of Chemistry
Probability and Statistics	Statistics Applied to Earth Sciences
Geology	General Geology
	Geomorphology
	Geochemistry
	Structural Geology
	Introduction to Pedology
	Geology of Venezuela
Hydrometeorology	Hydrosphere
	Physical Climatology
	Astronomy
Geodesy	Cartography and Photogrammetry
	Applied Cartography
	Territorial Planning
	Project in Earth Sciences
	Optional courses (Variables)

At the ULA, the profile of geography and Earth Sciences teachers is a specialist who knows the physical and sociocultural space of the Venezuelan territory, its potential and sustainable use, with training in TIC management. They are expected to have extensive information and communication skills, plus experience managing and executing territorial, environmental and social-cultural projects. Modifications to the study curriculum began in 2015 with the aim of integrating specialists in the social and productive processes of the environment, with a focus on meaningful learning. The specialty training courses are primarily the different branches of geodesy, geology, and geography.

Teachers trained in Earth Sciences education can cover disciplines in different levels of secondary education, such as First-Year Nature Studies or Geography disciplines in all years of basic education. Due to the demand for physics and chemistry specialists, those trained in Earth Sciences can teach these disciplines, at least in the third year of secondary education.

27.4 The discipline of earth sciences in middle education

The Earth Sciences discipline corresponds To the level general middle education, specifically the 5th year the education, with students ages of 15 to 18 years old. With a workload of only three hours per week, one for theory and two dedicated to practical activities in small groups, this short time allotment is concerning considering this discipline is of utmost importance for the country's main economic activities. Venezuela's economic dependence on oil and mining activities, plus the diversity of the Venezuelan geography and its exposure to natural hazards, requires an informed populace prepared to act before, during and after crisis events. Yet there no have been a few modifications made to the increase the Earth Sciences workload.

In Table 27.3 lists the Natural Sciences themes addressed in secondary education levels, with the Natural Sciences content, in particular Earth Sciences, mainly addressed in the fourth and fifth year, detailed in Table 27.4. There is Earth Science content between the first and third years, however these form parts of other disciplines that are usually taught by teachers from other areas without specialized Earth Sciences training.

Earth Sciences trained teachers in Venezuela generally do not receive a solid Biology training, yet they are obliged to instruct a variety of disciplines, including Biology. Therefore, it is worrisome that many teachers teach this discipline to complete their workload wekly of 36, 48 or 54 hours of weekly classes because Earth Sciences are only introduced in the 5th year of secondary education. although they can teach other disciplines, generally those of greater demand are the disciplines of Physics, Chemistry, and Biology.

A curricular reform of secondary education began in Venezuela in 2002. During this reform, the Bolivarian High Schools and the Robinsonian Technical Schools were formed. In 2007, the Bolivarian Educational System (SBE). In 2012, the production and distribution of textbooks called the Bicentennial Collection began.

In 2015, continuing with this process of curricular change in secondary education, the curricular proposal is published, which establishes that it must be developed in the Bolivarian Secondary Schools from the beginning of the school year in September 2015.

With respect to the textbook of Earth Sciences of the Bicentennial, they are born as a proposal to update scientific content, as reflected by Andrés, et al (2014), the recognition of science as a social construction that generates knowledge, expanding this vision of theoretical experiments a bit, towards a more social context.

The books of the bicentennial collection have had a great impact at the national level, for free distribution, reaching the hands of students with limited resources, but it is important to note that they require constant updating and readjustments of many contents that, in my opinion, do not deepen, working in a very superficial way.

27.5 Elements of the curriculum related to earth sciences

Tables 27.3 and 27.4 below outline the Earth Sciences curriculum elements and the related content addressed in secondary education. The key Earth Sciences related subjects aimed at supporting a dynamic curriculum, introduced as of September 2015, are: the preservation of life on the planet, health and good living, oil and energy, and science, technology and innovation. Within the training areas proposed in the integration process, are the Natural Sciences, including Biology, Chemistry, Physics, Earth Sciences, Anthropology, and Health, among others.

Tab. 27.3 Central natural science curriculum topics. Taken from Curriculum Reform (2015)

Year	Generating Themes
First Year	- The research process in Science and Technology, Environment, Biodiversity and food sovereignty. - Integral health of living beings and their functions of nutrition with the environment. - Water and soil: Sources of life and food. - Matter and its transformations necessary for life. - Movement and interactions in social-productive activities.
Second Year	- Investigating in Science and Technology. - Threats of nature. Comprehensive risk management. - The integral health of living beings and their role in relation to the environment. - The planet Earth as a complex system - Matter reacts to changes. - Bone-muscle movement and its interactions with the environment.
Third Year	- Research projects in science and technology. - Socio-environmental effects of science and technology. - The fundamental piece of life: The cell and its changes. - Properties of water and its social distribution. - Light and sound. - Security and Road Education. Road culture of coexistence.
Fourth Year	- Research in science and technology at the service of good living. - Rational, responsible and sovereign use of water, oil and electric power as social production systems. - The sustainability of biodiversity at local, regional, national and global levels. - Terrestrial systems and life on the planet - Responsible and sovereign uses of inorganic matter. - The macroscopic phenomena of nature as sustainable systems of social production.

Fifth Year	- Research on community participation, researching, transforming and producing. - The petrochemical industry, electric power, and biotechnology for good living. - The integral health of living beings and their reproductive functions and relationship with the planet. - Venezuela on Earth: Save the planet. - Responsible and sovereign use of organic matter present in nature. - The microscopic phenomena of nature as sustainable systems of social production.

Tab. 27.4 Earth Sciences centered themes included in the fourth and fifth years of Secondary Education. Taken from the Process of Curricular Change in Secondary Education applied since September 2015

Year	Generating Themes
Fourth year	- The Earth Sciences and their implications. - Reading and interpreting maps, satellite images and other models. - Earth's home in the Universe. - Themes of conceptualization, systematization, and generalization: The Universe. - The Earth: a complex and living system. - Themes of conceptualization, systematization, and generalization: Geosphere. - Interactions in the Geosystem. - System focus. - Functioning of the terrestrial dynamics, it is superficial and internal effects. - Climate and weather: The troughs in the Bolivarian Republic of Venezuela. - Risk maps.
Fifth year	- Methods to determine ages of rocks. Geological cycles. - Physiography. Oil basins and reserves in Venezuela. Mineral deposits in Venezuela. - Complex climate. - Anthropocentrism. Development Economizer. - Earth Charter.

27.6 Weaknesses in venezuelan earth sciences teaching

The weaknesses mentioned below are at the discretion of the author and can be addressed with a broad national discussion and improved investment in the education system:

1. Teachers trained in Natural Sciences, especially Earth Sciences, require continuous training to maintain up-to-date classroom content. This is limited by the few offererings available from the Ministry of Power Popular for Education on pedagogical and specialized training courses nationally and internationally.
2. Few teachers actively participate in producing theoretical knowledge about learning processes and the respective implications in teaching Earth Sciences.
3. Earth Sciences teaching is, in many cases, limited to theory, as it is hampered by the lack of equipped laboratories and field practices. The

last key aspect is addressed within the 2015 curricular reform as one of the pedagogical strategies, but, unfortunately, it is generally limited by scarce resources for implementating these practices.

4. Teachers not trained in the discipline area they must teach is a concern for the importance it represents nationally.

5. The 2015 curricular proposal simplifies the Earth Sciences content, which should be called a deep rectification to extend and deepen the content. The texts destined for the Bicentennial Collection of Earth Sciences are: Kéller and Blodgett (2007) for natural risks; Tarbuck and Lutgens (2000), for Earth Sciences; and Craig, et al. (2007), for Earth Resources: origin, use, and environmental impact.

27.7 Final considerations

Venezuela's participation in the International Earth Science Olympiad (IESO) is not currently included in the 2015 curricular reform, nor in the programmed activities of the Ministry of the Popular Power for Education. The participation of Venezuelan students, which would represent an important future activity of academic and cultural exchange in the public sphere, is not currently under consideration.

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