Earth Sciences

Introduction to the Earth Sciences

Earth Sciences focuses on the understanding of Earth systems in order to learn from the past, understand the present and predict and influence the future. It deals primarily with a study of materials, processes and history of this and other planets. Earth Sciences provide a distinctive education by providing a systematic multi- and inter-disciplinary approach to complex natural systems. Comprehensive field training, a range of spatial and temporal analytical skills, and encouragement for graduates to use their powers of observation, analysis and imagination to make decisions in the light of uncertainty are all characteristics of an Earth Sciences degree.

It is taken as being self-evident that a knowledge and understanding of the Earth and its systems are of incalculable value both to the individual and to society at large, and that the first object of education in Earth Science is to enable this to be acquired. However, given the width of the subject, it is impossible to define a single core body of knowledge. Consequently a range of different approaches are required in the manner in which the vast body of knowledge which constitutes this subject is presented at undergraduate degree level throughout Europe.

The concepts, theories and methodologies of other sciences are themselves used by many earth scientists and applied to the Earth system. Therefore, training in relevant aspects of such basic disciplines will normally constitute a part of an Earth Sciences degree. It might also be appropriate to include relevant elements of humanities, economics and social sciences in degree programmes in Earth Sciences.

Earth Sciences also develop ways of thinking which are intrinsic to the discipline while being no less transferable. These include[1]:
1) a four dimensional view —the awareness and understanding of the temporal and spatial dimensions in earth process—;
2) the ability to integrate field and laboratory evidence with theory following the sequence from observation to recognition, synthesis and modelling;
3) a greater awareness of the environmental processes unfolding in our own time; and
4) a deeper understanding of the need to both exploit and conserve earth resources.

Degree profile(s)

Typical degrees offered in the Earth Sciences

Cycle	**Examples of Typical Degrees Offered**
First	Bachelors degrees tend to be holistic with a wide range of subject descriptors including: Geology (including Mineralogy; Petrology; Sedimentary Geology; Resource Geology; Structural Geology; Tectonics; Palaeontology; and Stratigraphy); Physical Geography (including Geomorphology), Soil Science, Hydrogeology and Hydrology, Geophysics; Geochemistry; Environmental Geology; Engineering Geology; Ocean Science and Environmental Science. Earth Sciences may comprise a significant component in multi-disciplinary degrees covering resources, environmental management and planning, the atmosphere, climate and palaeoclimate.

[1] This list is indicative, not prescriptive.

Second	Masters degrees may be purely by research or, more typically, by a mixture of course work and a substantial thesis component, usually involving one of the sub-disciplines listed above. A significant number of such courses have a strong vocational component.
Third	Doctorate by research, usually requiring examination and defence of a substantial and original piece of research described in a comprehensive thesis

Typical occupations of the graduates in the Earth Sciences (map of professions)

Cycle	**List of professions related to Earth Sciences**
First	Trainee level earth scientist (“Junior geologist” etc.) Teacher in secondary education (initial years) in earth science /geography/science
Second and Third	Industry (hydrocarbons, minerals etc.) Public offices (Survey, Research Institutes etc.) Consultancy (private agencies, personal) Universities (Research and education) Public offices (various agencies concerned with soil, water, physical planning, natural hazards, environmental conservation, agriculture etc). Also public Research Institutes Private companies (waterworks etc.) Teacher (Secondary School) in Earth Sciences /Geography/Science Museum functions Engineering Geology Science journalist etc.

Role of Earth Sciences in other degree programmes

The Earth Sciences overlaps with other degree programmes such as environmental sciences, social science-based environmental studies, biology, chemistry, physics, mathematics, civil engineering, geography and archaeology. Earth Science is defined by many to include engineering geology, mining engineering, petroleum engineering and physical geography, while some would also include oceanography and meteorology. The Earth Sciences promotes an awareness of the dual context of the subject in society, namely that of providing knowledge and understanding for both the exploitation and the conservation of the Earth’s resources.

An Earth Sciences degree programme requires underpinning knowledge especially in the fields of Chemistry, Physics, Biology, Mathematics and Information Technology, some of which may properly constitute part of the Earth Sciences curriculum. Earth Sciences are also relevant to Law and Economics, Town and Country Planning, Human Geography, Politics and Sociology, and Management, Business and Safety studies. Students often receive instruction from outside the core department and may have an opportunity to gain joint degrees.

Learning outcomes & competences - level cycle descriptors[2]

First Cycle	
Key Subject Specific Competences	***Key Generic Competences***

• Show a broad knowledge and understanding of the essential features, processes, history and materials of System Earth. • Recognize the applications and responsibilities of Earth Science and its role in society. • Show adequate knowledge of other disciplines relevant to Earth Science. • Independently analyze earth materials in the field and laboratory and to describe, analyse, document and report the results. • Be able to reason in large-scale spatial and, or temporal frameworks • The application of simple quantitative methods to Earth systems.	• Work both independently and in a team • Basic general knowledge • Grounding in basic knowledge of the profession • Oral and written communication in your native language • Knowledge of a second language • Elementary computing skills • Information management skills • Awareness of safety • Ability to communicate Earth Science issues with the wider society
Second Cycle	
• To demonstrate a comprehensive knowledge in at least one specialized area of Earth Science • Be able to define, determine and implement a strategy for solving an Earth Science problem • To be able to understand the interactions of earth processes and test the results of these • To produce a substantial report or thesis (including an executive summary).	• Research skills • Capacity for analyses and synthesis • Problem solving • Information management skills (ability to retrieve and analyse information from different sources)
Third Cycle	
• Demonstrate the ability to perform independent, original and ultimately publishable research in the field of Earth Sciences	• Creativity • Critical and self-critical abilities • Capacity for generating new ideas (creativity)

Consultation process with stakeholders

The Earth Sciences profession is represented by learned societies, many of which have been established since the 19th century. Professional bodies have grown up at both national and European level by the end of the 20th Century, some having associations with these learned societies. Both of the above may offer degree accreditation. In many of the northwestern countries degree accreditation is provided for by national law. The extractive, mining and hydrocarbon industries have had a long tradition of liaison with university Earth Sciences departments as have national bodies such as Geological Surveys, Environmental Protection Agencies and Museums. In general, there is a healthy and ongoing debate about the relevance of Earth Science education to the needs of the profession and society.

Workload and ECTS

Cycle	**ECTS**

First	Mostly 180 ECTS or 240 ECTS.
Second	60, 90 or 120 ECTS.
Third	120 ECTS on completion of Masters, else mostly a minimum of 180 ECTS post-Bachelors

Many countries award a First Cycle Bachelors Degree after either 180 ECTS or 240 ECTS. The first model is currently the most common. There are still some individual programmes that differ from this model (150 ECTS and 210 ECTS) and are unlikely to change in the near future. Several countries are in the process of changing their existing programmes to fit the 'Bologna' Model. It is likely that both 180 ECTS and 240 ECTS models will be adopted and these may be programme, rather than country, specific. A variety of models exist for Second Cycle Masters Degrees which are awarded after 60, 90 or 120 ECTS. There is least standardisation at the Third Cycle level. Many countries require that the Doctorate be taken after the completion of a Masters Degree. In practice many students study for much longer than 3 years although some administrations are starting to penalise this practice.

Teaching, learning & assessment

The Group considers that it is inappropriate to be prescriptive about which learning, teaching or assessment methods should be used by a particular programme. This is because Earth Sciences programmes may (e.g. based on the requirements of different subdisciplines) be differently oriented and are embedded in diverse educational cultures within individual European countries. Different institutions, moreover, have access to different combinations of teaching resources and variable modes of study in addition to the traditional full time degree course. However, staff involved in course delivery should be able to justify their choices of learning, teaching and assessment methods in terms of the learning outcomes of their courses. These methods should be made explicit to students taking the courses concerned.

Learning, teaching and assessment should be interlinked as part of the curriculum design process and should be appropriately chosen to develop the knowledge and skills identified in the specification for the student's degree programme. Research and scholarship inspire curriculum design of all Earth Science programmes. Research-led programmes can develop specific subject-based knowledge and skills.

The Group believes that it is impossible for students to develop a satisfactory understanding of Earth Sciences without a significant exposure to field based learning and teaching. We consider this learning through experience as an especially valuable aspect of Earth Science education. We define «field work» as observation of the real world using all available methods. Much of the advancement in knowledge and understanding in our Earth Sciences is founded on accurate observation and recording in the field. In addition, fieldwork trains Earth Science students to formulate sound conclusions on the basis of (necessarily) incomplete data. Students and employers consider this an important aspect of their training. Developing field-related practical and research skills is, therefore, essential for students wishing to pursue careers in Earth Sciences. Additionally field-based studies allow students to develop and enhance many of the Graduate Key Skills (e.g. teamworking, problem-solving, self-management, interpersonal relationships) that are of value to all employers and to life-long learning.

Existing Earth Sciences programmes have developed and used a very diverse range of learning, teaching and assessment methods to enhance student learning opportunities. These methods should be regularly evaluated in response to generic and discipline-specific national and international developments and incorporated where appropriate by curriculum developers.

Best Practice

Method of Teaching, Learning & Assessment	*Some Key Competences Gained*

A field trip in which students are first shown a problem in the field, made rehearse the necessary skills and then required to analyse the problem (usually in small groups) and to report their results. This exercise is usually performed during the second and, or third year of a Bachelors programme.	• Work both independently and in a team • Be able to reason in large-scale spatial and, or temporal frameworks • The application of simple quantitative methods to Earth systems. • Oral and written communication in your native language • Awareness of safety • An appreciation of the complexity of the environment • Capacity for applying knowledge in practice
To conduct an internet search, at First Year Level, to investigate recent advances in the study of another planet (e.g. Mars). Usually some guidance is given in terms of useful sites to initiate the research. Students may work in groups or singly and must produce, in their own words, a summary of their discoveries. These should be presented at a student seminar and assessed by both fellow students and staff.	• Elementary computing skills • Information management skills • Work both independently and in a team • Capacity for analyses and synthesis • Be able to reason in large-scale spatial and, or temporal frameworks • Concern for quality • Oral and written communication in your native language
The analysis of a set of earth materials in the laboratory using a petrological or a binocular microscope with a view to placing these materials within an existing classification scheme. This exercise should include the description and recognition of the components (mineral, rock, or fossils) of the sample, the preparation of a clear, accurate record of this analysis and some quantification of the findings. Such samples may have been collected during a previous field trip.	• Elementary computing skills • Information management skills • Independently analyze earth materials in the field and laboratory and to describe, analyse, document and report the results. • Grounding in basic knowledge of the profession • The ability to accurately record and describe natural materials • Ability to work autonomously • Concern for quality

Quality enhancement

The Earth Sciences Subject Area Group, whilst recognising the importance of quality enhancement throughout all aspects of degree design and delivery, wishes to emphasize the role of field work in enhancing the quality of its degree programmes. The current trend towards a ‘compensation culture’, increasing costs and modularisation of degrees makes it increasingly difficult to implement a comprehensive fieldwork programme within the framework of a First Cycle Degree. Field instruction follows three models: demonstration of natural features by staff to large groups; small group problem solving; and individual or paired project work over several weeks analysing a field problem. All of these provide an unique opportunity to apply knowledge in practice and develop the competences necessary for the workplace. Professional societies normally require evidence that a graduate has undertaken considerable independent field work, either in the context of their degree studies and, or whilst supervised in the workplace, before giving professional recognition. Students find field work attractive and it encourages them to study science subjects which contain a field work component. A comprehensive, safe, well planned and managed field programme will enhance the quality of almost all Earth Sciences degree programmes.