Tuning

Tuning Educational Structures in Europe

Reference Points for the Design and Delivery of Degree Programmes in **Earth Science**

Education and Culture DG
Life Long Learning

Reference Points for the Design and Delivery of Degree Programmes in Earth Science

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Tuning Educational Structures in Europe

The name *Tuning* was chosen for the project to reflect the idea that universities do not look for uniformity in their degree programmes or any sort of unified, prescriptive or definitive European curricula but simply for points of reference, convergence and common understanding. The protection of the rich diversity of European education has been paramount in the Tuning Project from the very start and the project in no way seeks to restrict the independence of academic and subject specialists, or undermine local and national academic authority.

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1. Introduction

Tuning Educational Structures in Europe is a university driven project which aims to offer a universal approach to implement the **Bologna Process** at the level of higher education institutions and subject areas. The Tuning approach consists of a methodology to (re-) design, develop, implement and evaluate study programmes for each of the Bologna cycles.

Furthermore, Tuning serves as a platform for developing reference points at subject area level. These are relevant for making programmes of studies comparable, compatible and transparent. Reference points are expressed in terms of learning outcomes and competences. Learning outcomes are statements of what a learner is expected to know, understand and be able to demonstrate after completion of a learning experience According to Tuning, learning outcomes are expressed in terms of the *level of competence* to be obtained by the learner. Competences represent a dynamic combination of cognitive and meta-cognitive skills, knowledge and understanding, interpersonal, intellectual and practical skills, and ethical values. Fostering these competences is the object of all educational programmes. Competences are developed in all course units and assessed at different stages of a programme. Some competences are subject-area related (specific to a field of study), others are generic (common to any degree course). It is normally the case that competence development proceeds in an integrated and cyclical manner throughout a programme. To make levels of learning comparable the subject area groups/Thematic Networks have developed cycle (level) descriptors which are also expressed in terms of competences.

According to Tuning, the introduction of a three cycle system implies a change from a staff centred approach to a student oriented approach. It is the student that has to be prepared as well as possible for his or her future role in society. Therefore, Tuning has organized a Europe-wide consultation process including employers, graduates and academic staff / faculty to identify the most important competences that should be formed or developed in a degree programme. The outcome of this consultation process is reflected in the set of reference points – generic and subject specific competences – identified by each subject area.

Besides addressing the implementation of a three cycle system, Tuning has given attention to the Europe-wide use of the student workload

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based European Credit Transfer and Accumulation System (ECTS). According to Tuning ECTS is not only a system for facilitating the mobility of students across Europe through credit accumulation and transfer; ECTS can also facilitate programme design and development, particularly with respect to coordinating and rationalising the demands made on students by concurrent course units. In other words, ECTS permits us to plan how best to use students' time to achieve the aims of the educational process, rather than considering teachers' time as a constraint and students' time as basically limitless. According to the Tuning approach credits can only be awarded when the learning outcomes have been met.

The use of the learning outcomes and competences approach might also imply changes regarding the teaching, learning and assessment methods which are used in a programme. Tuning has identified approaches and best practices to form specific generic and subject specific competences.

Finally, Tuning has drawn attention to the role of quality in the process of (re-)designing, developing and implementing study programmes. It has developed an approach for quality enhancement which involves all elements of the learning chain. It has also developed a number of tools and has identified examples of good practice which can help institutions to boost the quality of their study programmes.

Launched in 2000 and strongly supported, financially and morally, by the European Commission, the Tuning Project now includes the vast majority of the Bologna signatory countries.

The work of Tuning is fully recognized by all the countries and major players involved in the Bologna Process. At the Berlin Bologna follow-up conference which took place in September 2003, degree programmes were identified as having a central role in the process. The conceptual framework on which the Berlin Communiqué is based is completely coherent with the Tuning approach. This is made evident by the language used, where the Ministers indicate that degrees should be described in terms of workload, level, learning outcomes, competences and profile.

As a sequel to the Berlin conference, the Bologna follow-up group has taken the initiative of developing an overarching *Framework for Qualifications of the European Higher Education Area* (EQF for HE) which, in concept and language, is in full agreement with the Tuning approach. This framework has been adopted at the Bergen Bologna follow-up conference of May 2005. The EQF for Higher Education has made use of the outcomes both of the Joint Quality Initiative (JQI) and of Tuning. The JQI, an informal group of higher education experts, produced a set of criteria to distinguish between the different cycles in a broad and general manner. These criteria are commonly known as the "*Dublin descriptors*". From the beginning, the JQI and the Tuning Project have been considered complementary. The JQI focuses on the comparability of cycles in general terms, whereas Tuning seeks to describe cycle degree programmes at the level of subject areas. An important aim of all three initiatives (EQF, JQI and Tuning) is to make European higher education more transparent. In this respect, the EQF is a major step forward because it gives guidance for the construction of national qualification frameworks based on learning outcomes and competences as well as on credits. We may also observe that there is a parallel between the EQF and Tuning with regard to the importance of initiating and maintaining a dialogue between higher education and society and the value of consultation — in the case of the EQF with respect to higher education in general; in that of Tuning with respect to degree profiles.

In the summer of 2006 the European Commission launched a European Qualification Framework for Life Long Learning. Its objective is to encompass all types of learning in one overall framework. Although the concepts on which the EQF for Higher Education and the EQF for LLL are based differ, both are fully coherent with the Tuning approach. Like the other two, the LLL variant is based on the development of level of competences. From the Tuning perspective both initiatives have their value and their roles to play in the further development of a consistent European Education Area.

This brochure reflects the outcomes of the work done by Earth Science Subject Area Group so far. The outcomes are presented in a template that was developed to facilitate readability and rapid comparison across the subject areas. The summary aims to provide, in a very succinct manner, the basic elements for a quick introduction into the subject area. It shows in synthesis the consensus reached by a subject area group after intense and lively discussions in the group. The more ample documents on which the template is based are also included in the brochure. They give a more detailed overview of the elaborations of the subject area groups /Thematic Networks.

The Tuning Management Committee

2. Introduction to Earth Science Subject Area Group

Earth Science Subject Area Group (ESSAG) (Annex 1), originally known as the Geology Subject Area Group, has been part of the Tuning Project since its inception. At a very early stage there was agreement on three aspects of Earth Science within the European Higher Education Area (EHEA). Firstly, there was a consensus on the competences necessary to produce a graduate Earth Scientist accompanied by the realisation that we could each learn from the richness and diversity of other Higher Educational Systems in Europe. However, we were faced with the challenge of trying to formulate this accord and we trust that this document may go some way to achieving this goal. Secondly, the enormous breadth of subjects that fall within the remit of Earth Science (let alone the wider Earth System Sciences) meant that the ESSAG was extremely careful not to recommend a 'standard curriculum'. Nevertheless we tried to elucidate the fundamental underlying Generic and Subject Specific competences which are required to study the Earth. Finally, we are adamant that any Earth Science training programme should include an appropriate amount of field work, particularly at the Cycle 1 level. We believe that it is impossible to properly analyse and interpret field based data, whether collected directly or remotely, without an understanding of its inherent limitations.

This document is organised as follows. An *Introduction* to the Tuning Project and this subject area introduction are followed by the section, *Earth Science* which summarises the situation by briefly defining Earth Science and outlining their relevance to other subject areas and the workplace. It is based on the work of the Tuning 1 (Tuning 2003) and Tuning 2 (Tuning 2005) Projects. The second section, *Learning Outcomes and Competences*, identifies key generic and subject specific competences and gives practical examples (Annex 2) of how these are developed throughout the various Cycles within the EHEA. The next section, *Teaching, Learning and Assessment* (TLA), offers examples of methods for TLA in Earth Science and some advice on best practice in curriculum design. The section, *Third Cycle Degrees in Earth Science within the EHEA,* is a discussion document on the ESSAG's views on how the Doctorate Degree should evolve within the Bologna Process. These documents are developed from the web based products of Tuning 1, Tuning 2 and Tuning 3 with some re-organisation to enhance clarity. The link to the web site containing a glossary of terms used in these documents is given in the resource list (Section 7.2).

Sadly, the ESSAG has lost two of its valued members, Wim Roeleveld (Co-Chair for Tuning II) and Jean-Louis Mansy. Both played a vital part in helping us meld and understand different educational systems across Europe. They did this with firmness, wisdom and humour. We wish to publicly acknowledge their contribution to Earth Science Higher Education throughout Europe by dedicating this report to their memory. May they rest in peace.

3. Earth Science

Earth Science 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 Science 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 Science 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 Science degree. It might also be appropriate to include relevant elements of humanities, economics and social sciences in degree programmes in Earth Science.

Earth Science also develops 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.

1 This list is indicative, not prescriptive. A fuller treatment of this matter is given in Tuning (2003) pp. 137-144.

3.1 Degree profile(s) within Earth Science

3.1.1. Typical degrees offered in Earth Science

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, Geomorphology, Soil Science, Hydrogeology and Hydrology, Geophysics; Geochemistry; Geodesy; Environmental Geology; Soil Sceince; Engineering Geology; Ocean Science and Environmental Science. Earth Science may comprise a significant component in multi-disciplinary degrees covering resources, environmental management and planning, the atmosphere, climate and palaeoclimate.
Second	Masters degrees often have a strong vocational component and comprise both a course work and a thesis component. Academic Masters degrees also exist, usually involving one or more of the sub-disciplines listed above. These may be purely by research or involve coursework and a strong thesis component.
Third	Doctorate by research, usually requiring examination and defence of a substantial and original piece of research described in a comprehensive thesis. The research undertaken during this period of training should contain material that is either worthy of publication, or has been published by the student.

3.1.2. Typical occupations of the graduates in Earth Science (map of professions)

Cycle	List of professions related to Earth Science
First	• Trainee level earth scientist ("Site geologist" etc.) • Teacher in secondary education (initial years) in Earth Science /Geography/Science
Second and Third	• Exploration Industry (hydrocarbons, minerals etc.) • Consultancy (private agencies including those involved in site survey, environmental management and risk assessment) • Universities (research and education) • Public offices (Geological Surveys, Environmental Research Institutes including various agencies concerned with soil, water, physical planning, natural hazards, environmental conservation, agriculture etc) • Related industries (water suppliers etc.) • Teacher (Secondary School) in Earth Science /Geography/ Science • Museum functions. • Science journalist etc.

3.1.3. The Role of Earth Science in other degree programmes

Earth Science 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. Earth Science 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 Science 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 Earth Science curriculum. Earth Science 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.

3.2. Consultation process with stakeholders

The Earth Science 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 20thCentury, some having associations with these learned societies. Both of the above may offer degree accreditation. In many of the north-western 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 Science 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. The internationalisation of the Geoscience profession (Norbury, 2004) may well lead to a more regulated market than currently exists. It is important that this process involves closer links between all stakeholders.

3.3. Quality enhancement

The Earth Science Subject Area Group recognises the importance of quality enhancement throughout all aspects of degree design and delivery. Earth Science training requires a wide range of teaching methods within the classroom, laboratory and in the field. However, we wish to emphasize the role of problem solving tasks within Earth Science education. The current trend towards a 'compensation culture', increasing costs and modularisation of degrees makes it increasingly difficult to implement a comprehensive fieldwork programme or work experience programmes within the framework of a First Cycle Degree. 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 awarding 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 Science degree programmes.

4. Learning Outcomes & Competences

4.1. Key Competences for Earth Science

The Group identified the competences summarised in the table below as being those which should characterise an Earth Science degree programme. This table was complied from: analysis of the results from the Tuning I Survey (Tuning 2003, pp. 273-297); round table discussion; and completion of a competence matrix by representatives from different countries (see below). It is assumed each successive Cycle will add new competences onto those already obtained.

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 • A grounding in basic scientific methodology • 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 • An awareness of the importance of life long learning

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Second Cycle	
Key Subject Specific Competences	***Key Generic Competences***
• 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) • An awareness of economic factors, especially in those courses with a strong vocational component.
Third Cycle	
Key Subject Specific Competences	***Key Generic Competences***
• Demonstrate the ability to perform independent, original and ultimately publishable research in the field of Earth Science	• Creativity • Critical and self-critical abilities • Capacity for generating new ideas • Scientific leadership

4.2. Table of Educational Activities and the development of competences

A large number of teaching methods are used in Earth Science degree programmes and the Group did not wish to be restrictive in their choice of methods. Rather we offer the matrix in Annex 2 as an example of how particular Subject Specific and Generic competences are developed in Earth Science programmes in different countries. These are accompanied by the commentaries from individual member countries on how these competences are developed in their programmes.

4.3. Competence development in Earth Science, particularly Field Studies

A comprehensive review of teaching methods is given in the Physics SAG report for Tuning III (see Section 7.2). The Group accepts this matrix and does not wish to be prescriptive in which of the many methods listed should be used to develop the required competences. All have a place in certain contexts. However, the teaching of Earth Science involves a variety of field study methods that are specifically tailored to the needs of the curriculum, or, indeed, that of other field based empirical sciences. These and the competences they are designed to develop are outlined in the matrix below.

Method of TLA	Some Key Subject Specific Competences Gained	Some Key Generic Competences Gained
Students are taken on a **field trip** or a **site visit**, often in large numbers, to a natural or man-made feature. Various properties and processes are demonstrated and they are required to take notes, make sketches, take photographs and samples and appropriate measurements. This is usually guided by following a problem sheet. A short report must be written which is assessed along with the field notes. This exercise is suitable for the first year of a Bachelors programme or to students who are taking Earth Science as a minor component of their degree (e.g. Engineers)	• 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.	• Capacity to learn • Problem solving • Capacity for applying • knowledge in practice • Basic general • knowledge

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Method of TLA	Some Key Subject Specific Competences Gained	Some Key Generic Competences Gained
A **investigative 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 report is often then presented in seminar form and assessed by both teachers and other students. This exercise is usually performed during the second and, or third year of a Bachelors programme.	• Independently analyze earth materials in the field and laboratory and to describe, analyse, document and report the results. • The application of simple quantitative methods to Earth systems	• Work both independently and in a team • The application of simple quantitative methods to Earth systems. • Oral and written communication in your native language • An appreciation of the complexity of the environment • Capacity for applying knowledge in practice
A **field based project** which takes several weeks (the ratio of field to laboratory time is dependent on the sub-discipline) and may involve travel to other countries. Students are required to map some physical feature, collect and process samples or data, and present this in a report which is defended in front of examiners. This exercise may, for operational or safety reasons, be done singly or in pairs. However, each individual's contribution must be clearly identified and assessed.	• Be able to reason in large-scale spatial and, or temporal frameworks • Independently analyze earth materials in the field and laboratory and to describe, analyse, document and report the results.	• Awareness of safety • Capacity for analysis and synthesis • Problem solving • Capacity for applying knowledge in practice • Decision-making • Concern for quality • Information management skills • Ability to work autonomously • Critical and selfcritical abilities • Oral and written communication in your native language • Capacity for generating new ideas (creativity) • Ability to work in an international context

4.4. Workload and ECTS

The current situation is reviewed in the table below:

Cycle	ECTS
First	Mostly 180 ECTS or 240 ECTS.
Second	60, 90 or 120 ECTS.
Third	Most countries do not formally assign ECTS to the Cycle 3 programme (see discussion document on the Cycle 3 Degrees). The requirement tends to be in time with a minimum of 2 years full-time on completion of a Masters, else mostly a minimum of 3 years post-Bachelors. The mean times range between 3 and 5 years with a median value of about 3.5 years.

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. A discussion paper concerning the current situation and future development of Third Cycle Degrees in Earth Science is presented in Section 6. below.

4.5. Workload calculation

The total number of hours per undergraduate year varies throughout the EHEA from about 1200 to about 1680. This means that the range of hours per ECTS varies from 20-28, with a median at perhaps 25. The ratio of student contact hours to total workload also varies between and within subjects. Compare, for example, this ratio for a First Year lecture and practical based course versus that for a Final Year independent field mapping project. It is, therefore, impossible to offer any simple formula for such calculations. However, we offer the Tables in Annex 3 as an example of how such a calculation should be attempted. Please note that, following Tuning methodology, as well as the staff member calculating the desired workload, the student is asked to assess the actual workload.

5. 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 Science programmes may (e.g. based on the requirements of different sub-disciplines) 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 Science 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 Science 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 Science. Additionally field-based studies allow students to develop and enhance many of the Graduate Key Skills (e.g. team working, problem-solving, self-management, interpersonal relationships) that are of value to all employers and to life-long learning.

Existing Earth Science 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 which may be incorporated, where appropriate, by curriculum developers.

5.1. TLA and Competence Acquisition

We offer 3 examples of best practice below to illustrate how different methods of Teaching, Learning and Assessment is linked to the acquisition of competences by the student. A full list of Generic and Subject Specific Competences used in the Tuning 1 Survey is given by Tuning (2003, Annex 1).

Method of Teaching, Learning & Assessment	Some Key Competences Gained
A laboratory exercise requiring analytical skills (e.g. the effects of human activity on groundwater chemistry). Students first learn the context, environmental consequences and possible cost factors associated with remediation of such a problem. They then rehearse the necessary skills (experimental design, sampling programme, required analytical and reporting techniques). They are then required to analyse the problem (usually in small groups) and to report their results. Such an exercise is suitable for the second and, or third year of a Bachelors programme. Assessment could include critical evaluation of: experimental design; sampling programme and recording of associated field data; analytical results; statistical treatment of data and errors; suggested actions; the top copy report; a group presentation and, or defence of the product before 'clients'. Competences obtained may also be assessed in written exams.	• 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 the students native language • Awareness of safety both in the laboratory and field • An appreciation of the complexity of the environment • Capacity for applying knowledge in practice • Basic scientific methodologies of problem formulation, investigation, analysis and resolution.

Method of Teaching, Learning & Assessment	Some Key Competences Gained
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. Students should be warned against plagiarism and taught the importance of correct citation..	• 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 the students native language • Recognition of some moral and ethical issues associated with scientific investigation.
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. Assessment will include both the quality of observation as well as that of presentation and interpretation.	• 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

5.2. Best Practice in Curriculum Design

- We acknowledge the diversity of Departmental structures but recognise that a 'Director of Studies' can play an important role in the design and management of the delivery of each programme. A broad spectrum of academic staff views should also be heard so that the curriculum and educational approach is understood and supported by both staff and students.
- The general **purposes** and **learning outcomes** of each study programme should be stated. They should take into account both the needs/expectations of students and the academic character of the discipline. Moreover, external influences and changes, both national and international, as well as the mission of the university, should be considered.
- For each study programme there should be a qualification **profile** that clearly defines the aims and objectives of the programme. Extra clarity can be obtained by expressing objectives in terms of the intended learning outcomes (statements of what the graduates should know, understand and be able to do), expressed as generic and subject-related competences to be achieved. Curriculum design and student assessment should refer to this qualification profile of the graduates.
- The curriculum design process should consider the academic content and **level** to be reached but it should also consider that one major achievement in HE is to promote autonomous learning and autonomous learners, which has an implication for teaching and learning methods and the overall **workload** placed on the students. As long as the objectives of the programme are met, the curriculum design should not overload students with excessive and redundant content. Curriculum design should consider the employability of graduates as well as their academic and intellectual training.
- An **evaluation** scheme should be in place to monitor and review the operation of each study programme. This should consider both educational quality and academic standards. The monitoring process should involve the systematic collection and analysis of statistical information on key indicators such as examination success rates, progression of students to employment or higher degrees, student recruitment numbers, response to evaluative questionnaires, institutions feedback, etc. The review process should be periodic and should involve experienced external subject experts as well as quality specialists from the same

university. The results of the reviews should be published within the university.

- Various **feedback loops** should operate. These should involve students, alumni and academic staff but they may operate with different time-scales. In particular, there should be provision for obtaining and acting on information from student questionnaires and from student representatives. The purpose of the feedback loops is to correct deficiencies in delivery and/or design of the curriculum.

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6. Third Cycle Degrees in Earth Science

6.1. Review of the current situation

Members' Institutions mainly run Ph.D. (Research) based 3rd Cycle programmes. Admission to these programmes is usually after a Cycle 2 degree and may also involve an entrance exam. The 3rd Cycle degree is completed in between 3 to 5 years with a median value at about 3.5 years. Longer completion dates may reflect the fact that the student is funded by a teaching fellowship, which in effect makes the degree part-time. The proportion of part time students varies from 0% to 50% with a median of about 20%. In most countries, students work as teaching assistants whilst they are studying. This is often limited to a few (six?) hours a week. Supervision in the laboratory and field is provided by staff member(s) and, in about one quarter of the institutes surveyed, the Faculty also provides a follow-up group. Assistance in both the laboratory and field is often supplied by technical staff. Safety, particularly in the field, is the prime responsibility of the student with varying amounts of guidance from the supervisors and other officers of the institution. Most institutes try to recruit internationally, although the proportion of foreign students may be as low as 10% in some cases. About one third of the countries have a formal publication requirement before the degree can be awarded. Similarly, about the same proportion allow submission of either a set of publications (perhaps 5-6 papers) or a monograph style thesis with the remainder requiring a traditional monograph style thesis. All states accept theses written in English in addition to one of their national languages. The format of the examination varies considerably. In most cases an oral examination of the thesis is required, whilst some require a public defence and others also insist on satisfactory completion of compulsory course work. Most, if not all, countries require at least one examiner to be external to the department or from abroad. Perhaps more than half of the countries grade their Doctorates, whilst others operate a simpler pass/fail system. The proportion of students who complete part of their studies abroad varies from about 10% to about 90%. Most countries do not have a formal academic credit accumulation requirement such as ECTS for their Doctoral programmes. Descriptors are not yet uniformly adopted. Funding comes from a variety of sources either from European programmes, National Research Bodies and Academies, the Universities, industry or the students themselves. However, the ESSAG feel that 3rd Cycle studies are under-funded and would benefit from more European, national and industrial support. A recent survey shows that Earth Science and related disciplines produce some 8% of European Doctorates (Lola, 2004).

> *The word 'research' is used to cover a wide variety of activities, with the context often related to a field of study; the term is used here to represent a careful study or investigation based on a systematic understanding and critical awareness of knowledge.*
>
> *The word is used in an inclusive way to accommodate the range of activities that support original and innovative work in the whole range of academic, professional and technological fields ...*
>
> **Box 1: Extract from the definition of the term 'research' as used in the Dublin Descriptors (see 7.2)**

6.2. 'Professional' Doctorates

Although most current Cycle 3 programmes are research based programmes, there was some sympathy for awarding Professional Doctorates on the basis of long practice in Earth Science industry. However, the ESSAG strongly recommend that:

1. the award of such a Doctorate should be based mainly upon a body of 'research' as defined in the Dublin Descriptors Glossary (Box 1);
2. all Cycle 3 degrees must be rigorously examined at the same level as Ph.D. Style Doctorates;
3. only Universities should be allowed to award 3rd Cycle degrees;
4. There should be no CPD (Continuous Professional Development) requirement for a 3rd Cycle degree, as CPD is verified by the Professions not the Universities;
5. Innovation in Technology should be accepted as valid research.

Areas that need further work and agreement between the Earth Science Profession and participating universities are

- Definition of the time window for Professional Doctorates, perhaps a body of research over 5 year period might be suitable. Such Doctorates must, as is the practice with Ph.D.s, be subject to a time limit to ensure a suitable intensity of study and research;
- Proof will be required that the work was produced personally by the candidate. If that candidate was part of a team, the body of work attributable to the candidate must be clearly identifiable;
- Research work must be capable of assessment, it cannot be hidden in confidential industry reports;
- The exact balance between the competences acquired by professional training at a post-2nd Cycle level and the research requirement must be elucidated. This would be equivalent to the generic competences training requirement for a Ph.D. Perhaps the research component should not be less than the equivalent of two years full time study at 3rd Cycle level?

6.2.1. Summary

The SAG was not prescriptive about the route to a 3rd Cycle Degree. However, standards must be maintained, and any Doctorate must have a significant research component.

6.3. ECTS

The ESSAG strongly recommends that an ECTS total should not be required for a 3rd Cycle degree. The danger in doing so is that it would create an impression that a Ph.D. or a Professional Doctorate can be gained by summing individual courses rather than a substantial body of research. If a doctoral programme was ECTS based there could be many students taking exactly the same courses, this would not be consistent with some of the descriptors for the 3rd Cycle (Box 2). However, it was recognised that some countries already use ECTS within the 3rdCycle, either as entry credits or to define the full 3rd Cycle programme. However, it was noted that where the programme was defined in ECTS the majority was assigned to research activities (e.g. Hungary requires 120-90 ECTS).

- have demonstrated the ability to conceive, design, implement and adapt a substantial process of research with scholarly integrity;
- have made a contribution through original research that extends the frontier of knowledge by developing a substantial body of work, some of which merits national or international refereed publication;

Box 2: Extract from the Dublin Descriptors (see Section 7.2)

Other countries require students to gain 'credits' for such activities as publications, presentations of papers or posters. It seemed to the ESSAG that where ECTS credits were applied to a Doctoral Programme they did not correspond directly to the ECTS credits awarded in 1st or 2nd Cycle Degrees. For example, they almost certainly do not currently constitute a valid system for the transfer of credit at the 3rd cycle level throughout Europe.'

However, the ESSAG did feel that ECTS, recorded in a Diploma Supplement, could form a limited part of a Doctoral Programme. Such credits could be used to:

- formalise and limit generic competence training, such as training in teaching methods;
- allow Departments outside of the student's host department, or indeed host university, to get credit for supplying specialist training;
- Allow credit for and to enforce requirements for students to attend relevant activities such as research seminars.

We note that ECTS awarded for such activities would be transferable. The ESSAG would strongly suggest that the number of such ECTS required within a Ph.D. Programme should be kept fairly low with, perhaps, 30 ECTS being the maximum permissible.

6.3.1. Summary

The assessment should be based on a body of research described in a thesis and, or publications. Some systems may use internal credits to monitor progress. The use of ECTS should be limited and preferably only applied in a very limited and appropriate manner.

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6.4. Funding

There is a lack of adequate, transparent and consistent funding for 3rd Cycle Degrees in Earth Science. Industry has a good tradition of supporting 3rd Cycle research and training, however, such funding is strongly influence by commodity prices, as is recruitment. At times of high commodity prices funding is available but students are not, as they enter the work place often with 1st Cycle degrees. At times of low commodity prices the opposite is true. The lack of strong, trans-European public-private funding structures must also influence our global competitiveness as our economic competitors are seeking to recruit proportionately more European 1st or 2nd Cycle students to their Doctoral Programmes.

> *'It is difficult to have a strategic and long-term vision for research when funding is too low and irregular* (Lola, 2004)'.

7. The Validation Process

As part of the Tuning validation strategy, the material which forms this Earth Sciences Tuning brochure was submitted to a panel of six international experts at the end of February 2007, care of the Tuning General Coordinators, who asked the panel to review the content. The panel and the Earth Sciences Subject Area Group (ESSAG) met in Brussels on March 23rd 2007, where a preliminary oral report was presented to the ESSAG by the panel at a plenary meeting. The panel was asked to respond to the following questions:

- Is the description of the subject area complete, clear and relevant: what do the Validation Panel members think about it?
- Degree profiles and occupations: how clear are they, are they complete, etc.
- Relevance of subject specific competences; do they emphasize certain competences more, or less?
- Relevance of generic competences; do they emphasize certain competences more, or less?
- With regard to the length of studies, the Panel members are asked what they think of the Tuning approach to workload.
- With regard to Teaching, Learning and Assessment what do the Panel members think of the Tuning approach?
- With regard to Quality enhancement the Panel members are asked what they think of the Tuning approach?

This report was discussed at the subsequent meeting of the ESSAG on 24th March 2007.

The Group thought that both the Validation Meeting and the subsequent Plenary Session were useful and productive and many of their suggestions were adopted which helped clarify and improve this document. The ESSAG would like to thank the panel for their valuable contribution to the Earth Science Tuning Project.

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8. References and Resources

8.1. References

Lola, M. 2005. "Doctoral Programmes for the European Knowledge Society", Bologna Seminar, Salzburg, February 2004).

Norbury, D. 2004. Current Issues Relating to the Professional Practice of Engineering Geology in Europe. *Lecture Notes in Earth Science, Springer Berlin / Heidelberg, 104,* 15-30.

Tuning, 2003. Tuning Educational Structures in Europe, Final Report, Phase One.

Tuning 2005. Tuning Educational Structures in Europe II.

8.2. Resources

The Tuning Glossary can be found at the link below:
http://tuning.unideusto.org/tuningeu/images/stories/GLOSSARY.pdf

The main Tuning website which contains all the Tuning III documents and Tuning I and Tuning II publications in pdf format is located at:
http://www.unideusto.org/tuningeu/

A detailed subject benchmark for Earth Science can be found at:
http://www.qaa.ac.uk/academicinfrastructure/benchmark/honours/history.asp

The full text for the (October 2004) Dublin Descriptors resides at:
http://www.uni-due.de/imperia/md/content/bologna/dubli-descriptors.pdf

The discussion document on the European Qualifications Framework (EQF) can be found at:
http://ec.europa.eu/education/policies/educ/eqf/com_2006_0479_en.pdf

The links between the Dublin Descriptors and the EQF link is given in:
http://bologna.hrdc.bg/pdf/sem/01_06/supporting/DUBLIN%20DESCRIPTORS.pdf

Annex 1: Membership of Earth Science SAG

This report was compiled by Paul D Ryan and represents the considered view of the Earth Sciences Subject Area Group.

A. Anceau	Liège, BE
F . Beunk	Vrije, Amsterdam, NL
G Boulton,	Edinburgh, Scotland
A. Canals	Bareclona, ES
B. Delpouve	Lille, FR
F. Dramis	Roma Tre, IT
S. Gehör	Oulu, FI
R Greiling	Heidelberg, DE
N. Tvis Knudsen	Aarhus, DK
J-L Mansy†	Lille, FR
F. Meilliez	Lille, FR
P. Nogueira	Èvora, PT
E. Pereira	Aveiro, PT (Co-Chair, Educational Expert)
K. Petrakakis	Wien, A
W. Roeleveld†	Vrije, Amsterdam, NL
P. Ryan	Galway. IE (Co-Chair)
D. Sanderson	Imperial College, UK
B. Stabell	Oslo, NO
T. Weiszburg	Eôtvos Loránd, HU

Plus past members:

R. Dias, Èvora, PT; R Kinghorn, Imperial, London, UK; P. Santanach, Barcelona, ES.

† Jean-Louis Mansy and Wim Roeleveld passed away whilst active members of this project.

Annex 2: The Competences Matrix

The matrix below offers example of how several important Generic and Subject Specific competences are developed in Earth Science third level education in both Cycle 1 and Cycle 2 degrees throughout member countries.

A2.1. Generic Competences, Cycle 2

COMPETENCE: Capacity for analysis and synthesis (Scotland)

What does this competence mean for your students?

Scottish master's programme tends to be directed towards highly specific professional knowledge. In the majority of cases the master's programme is an end in itself and not a stepping stone to PhD programmes

How do you help students to achieve this competence in your teaching methods?

As a consequence this competence is developed through highly specific, subject-focused work. In general it attempts to understand the most fundamental assumptions that underlay specific areas of knowledge to track the links in the reasoning chain that have led to contemporary concepts, and to assess, wherever possible in quantitative terms, uncertainties in data, analysis and synthesis.

What learning activities do your students engage with in order to develop this competence?

- Individual problem-based work
- Group problem-based work
- Masters thesis
- Oral presentation

How do you assess whether, or to what degree, they have achieved this competence?

- Through assessment of written and oral presentations,
- Through tutorial discussions

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How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

Through almost continuous feedback in writing on written work, orally in response to oral presentations and in tutorials.

COMPETENCE: Problem solving (England)

What does this competence mean for your students?

- The main impact of the problem solving approach is that students are constantly faced with the question of 'How' or 'Why' geological phenomena and processes occur. This provides their study with aims, rather than simply developing learning towards some ill-defined outcome.
- Students become more aware of why they are being taught things and being set tasks. As a result, they both understand and question what they are doing more.

How do you help students to achieve this competence in your teaching methods?

- Set aims for courses and place each course (or part thereof) in a wider context of the curriculum and development of the subject in general.
- Set aims for every lecture, practical class and field exercise.
- Place more emphasis on rationale and methodology than on attaining a correct result (the latter should follow if the former are in place).

What learning activities do your students engage with in order to develop this competence?

- Simple problem solving exercises.
- Comprehension, analysis and criticism of published research papers.
- Students undertake the design of their own independent research project, including the writing of a research proposal.

How do you assess whether, or to what degree, they have achieved this competence?

- Setting of 'unseen' problems, rather than testing of students ability to repeat old exercises

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How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

- Confidence in tackling new problems.
- Ability to deal with 'unseen' questions.
- An independent research project (based on field and/or laboratory work) is carried out as a major part of the 2nd cycle, which contributes to 37.5% of the assessment. Students first produce a research proposal, which is assessed by staff and forms the basis of the project. Students make an oral presentation of progress during their research; this is again assessed by staff and feedback given. Students are encouraged to present their projects in the form of a paper for journal publication. This is evaluated by two independent staff, who viva the student on the basis of their report. Students have a separate viva with an external examiner.

COMPETENCE: Decision Making (Spain)

What does this competence mean for your students?

This competence helps the students choose and establish the priority of different facts and concepts that they need to reach a particular educational objective

How do you help students to achieve this competence in your teaching methods?

This is mainly achieved by setting practical tasks that are supervised by an instructor

What learning activities do your students engage with in order to develop this competence?

Fieldwork is an example where this competence can be developed by setting students an assigned task which requires resolution.

How do you assess whether, or to what degree, they have achieved this competence?

Both by discussion and positive criticism of their result with the student and in both written and more formal oral reports

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

Such exercises are graded and feedback is given by the instructors.

COMPETENCE: Ability to work autonomously (Netherlands)

What does this competence mean for your students?

This competence is considered the main characteristic of university-educated students, when compared to students in other forms of (higher) education. In the context of the EU it is the main guarantee for the continuous development of democratic liberties and structures and hence an invaluable, and probably the most important, contribution to society in general.

How do you help students to achieve this competence in your teaching methods?

The first thing is for staff, recognising that there is a difference in experience and position, to educate students in a manner which at the same time stimulates both self-confidence and awareness of responsibility. This is very much dependant on the abilities and inspiration of individual members of staff and can hardly be organised in a formal way. However, some structural elements may help:

-involving students, whenever relevant, in a serious manner in departmental/university decision-making and practice, i.e. as formal assistants and as co-authors; - stimulating, within the limits of university responsibility, especially second cycle students to autonomously organise and realise their programme of studies, avoiding premature staff intervention.

What learning activities do your students engage with in order to develop this competence?

- Writing an MSc thesis, conducting related field, laboratory and literature research, and preparing related publications and oral contributions;
- Following courses in other, often foreign, departments;
- Attending lectures by colleagues from outside the department;

How do you assess whether, or to what degree, they have achieved this competence?

Primarily the level of the MSc thesis is assessed. Achievements in courses in other and, or foreign departments are taken into consideration on the basis of credits (mostly ECTS) and local assessment

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

Primarily through feed-back discussions regarding the MSc thesis

COMPETENCE: Critical and self-critical abilities (Ireland)

What does this competence mean for your students?

- The ability to perform competently within the defined topic
- The ability to take over academic responsibility for the topic
- The ability to forecast and answer questions
- The ability to do good research

How do you help students to achieve this competence in your teaching methods?

- Students are required to write a 1500 word article for the internal geological publication which is refereed internally following normal guidelines
- Students are required at least once during their studies to give a post or a presentation at a conference and are helped with funding.
- Students are encouraged to attend departmental seminars and outside conferences

What learning activities do your students engage with in order to develop this competence?

- Require, as a formal part of the students training,
- that they participate in seminars and informal discussions on a variety of topics.

- The preparation of theses requires close consultation with the supervisor which involves rehearsal of such competences
- For taught cycle 2 degrees all students must participate in seminars which critically discuss research papers and must also prepare a literature review.

How do you assess whether, or to what degree, they have achieved this competence?

- All cycle 2 students receive a viva voce examination with an external examiner before award of their degree. This constitutes a formal part of the exam and students are specifically expected to show that they have developed such critical facilities.
- Feed back on their contribution to seminars or on their presentations.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

- Students are given a formal debrie(this should be 'debriefing) f after their viva voce exams and told what their final grade was and how the various competences contributed to this grade.
- Private debriefings with supervisors after presentations
- Criticism by staff members of first draft manuscripts
- Criticisms by external referees where manuscripts have been submitted for publication.

COMPETENCE: Capacity for generating new ideas (creativity) (Belgium)

What does this competence mean for your students?

This means that our students are able to produce an original work after a personal enquiry about a precise subject. The students choose the subject out of a list submitted by the teachers. Some students will propose their own subject. In this case, the subject has to be approved by the teachers.

Our students have to prove that they are able to generate new ideas in achieving two major works, i.e.:

- a thesis that they have to present at the end of the cycle
- a personal geological map covering an area of about 30 km^2.

How do you help students to achieve this competence in your teaching methods?

They are incorporated within a research team. Through discussions, we are looking to show them how to conduct a search. We also request from them that they collect all available information about the subject through bibliographic investigation, fieldwork. We encourage them to talk with different people who can assist.

What learning activities do your students engage with in order to develop this competence?

a) Thesis

During the work, we request from the students that they present orally the results that they gained from the beginning. This presentation helps the students to organize their first results. This is an exercise of oral presentation as well. After the presentation the teachers will discuss with every student and will give some advice on how to proceed with their personal work.

b) Geological map

Concerning geological maps, the teacher will spend one day on the field with every student in order to discuss the stratigraphic canvas, tectonics, and geological boundaries .

How do you assess whether, or to what degree, they have achieved this competence?

a) Thesis

At the end of the year every student has to write a report summarizing the main results which he gained. The report is examined by 3 or 4 teachers. The student has also to present orally the results of his work. Usually, all the students of the 2nd cycle and teachers attend this presentation. After the presentation, the teachers question the student to assess the knowledge acquired by the student about the subject.

b) Geological map

Concerning geological maps, every student has to produce a map, a geological section, a stratigraphic log, and a geological key.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

a) Thesis

Every student receives a mark for the work done. This mark is the sum of the marks attributed to the written report and to the oral presentation.

b) Geological map

After correction, the students recover the geological map with comments.

COMPETENCE: Ability to work in an interdisciplinary team (Finland)

What does this competence mean for your students?

This competence allows students to:

- increase the understanding the basic nature of sciences and the place of earth science within other sciences;
- develop the skills of communication and academic thinking;
- increase the skill of using subject specific theories, in referencing work and make spontaneous contribution in a social gathering;
- train in summarizing results and decision-making

How do you help students to achieve this competence in your teaching methods?

Some courses in geology, especially in environmental geology, draw students from other disciplines. These are applicable for interdisciplinary teaching in form of seminars, written or oral communications or project based learning.

A project, as a teaching method, in laboratory or field work linked to laboratory would be useful for interdisciplinary learning. For example: a programme has been planned in Geo-environmental Studies, which contains studies from a Geology Department and from a Department of Process and Environmental Technology.

What learning activities do your students engage with in order to develop this competence?

Working with people, who do not have background in Earth Science, inspires my students to orientate to the questions of own subject area and to share information in a social gathering.

Working in team will develop the skills in oral and written communication.

How do you assess whether, or to what degree, they have achieved this competence?

A common written or oral presentation (interdisciplinary seminar) or a work description of a project would be adequate for following the process and giving feed back of the success.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

Students prepare a self assessment and participate in confidential discussions.'

COMPETENCE: Knowledge of a second language (Portugal)

What does this competence mean for your students?

It enables communication with and learning from Earth Scientists from other countries. Knowledge of other languages facilitates employment and travel opportunities ***How do you help students to achieve this competence in your teaching methods?***Usually the students have a 7 year background in one or two foreign languages. During classes bibliography in foreign languages (papers and books) is recommended. There are some technical terms that are not translated but explained in the classroom.

What learning activities do your students engage with in order to develop this competence?

Most classes include bibliographical references in English, French and Spanish.

How do you assess whether, or to what degree, they have achieved this competence?

Usually there is no (I would insert the word 'formal' here which I think is what is meant) evaluation of this knowledge.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

The ability and ease of reading papers and books in foreign languages are not discussed with the students but they are always recommended.

A2.2. Generic Competences, Cycle 1

COMPETENCE: Capacity for applying knowledge in practice (England)

What does this competence mean for your students?

- The use of knowledge gained in lectures to carry out investigations of materials during laboratory sessions. At an early stage, this means combining knowledge of mineral structure, rock formation, palaeobiology, stratigraphy, tectonics, etc. with the development of observational skills to allow identification, classification and comparison of minerals, rocks, fossils, etc. and the analysis of geological structures and maps.
- Application of similar principles and methods in field situations.
- ***How do you help students to achieve this competence in your teaching methods?*** Introduction of laboratory sessions, coursework assignments **and field classes** at an early stage. In many of our courses we do not distinguish between 'lecture' and 'laboratory' time, and where possible use the same classroom for both activities.

- Provision of clear demonstrations of both the 'approach' and 'solution' to selected practical examples.
- Provision of adequate assistance from Graduate Teaching Assistants (GTAs) in practical classes.
- Regular tutorial sessions in early years.

What learning activities do your students engage with in order to develop this competence?

- Students learn to apply lecture-based knowledge with observational and practical skills.
- For example, map-interpretation classes use the basic principles of stratigraphy and structural geology, together with aspects of many other subjects, to develop skills in the qualitative and quantitative analysis of field relationships and the prediction of sub-surface structure. Map interpretation problems may be aimed at the solution of practical problems in areas of economic geology (e.g. reserve estimation).
- Students learn to work independently and in small groups.
- They are encouraged to ask each other questions and to check their progress with GTAs.

How do you assess whether, or to what degree, they have achieved this competence?

- Inclusion of coursework components in assessment of most courses.
- Clearly defined deliverables, usually involving identification of specific 'solutions' that will be assessed rapidly.
- Inclusion of practical problems in final assessment of courses, to test if individual students can apply knowledge to specific problems and materials.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

- Rapid feedback on submitted coursework.
- Much geological knowledge and skill development is progressive; hence graded exercises allow students and teachers to assess progress through increasingly complex applications.
- Final grades in practical and field courses.

COMPETENCE: Concern for Quality (Finland)

What does this competence mean for your students?

This competence provides:

- Opportunities to participate and have a say on teaching development work
- A chance to follow and evaluate the teaching practice at the department
- An opportunity to have an influence on focusing the teaching resources at department
- And helps develop the general understanding of the meaning of quality, i.e. towards accurate observation and recording

How do you help students to achieve this competence in your teaching methods?

The University has established a network of teaching development groups at each department. The members are collected from teachers (assistants, lecturer and professors) and students. This team coordinates the teaching development and informs of its work to the Council of the Department and to the teaching development unit of University administration. It makes an evaluation report every year and runs the feedback system. The Student Association assigns the student members to the group for a three year period.

What learning activities do your students engage with in order to develop this competence?

The general discussions of quality are expected to increase the team work skills.

This would train them to assess which is bad and which is good practice in teaching and it would generate ideas how to improve the existing teaching methods and core curricula.

How do you assess whether, or to what degree, they have achieved this competence?

A prerequisite for comprehensive quality responsibility and quality concern is the ability to estimate current situation, not only the quality of

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staff work (teaching practice), but more widely, the offered contents of general and subject related competences. At the beginning of studies the students are unlikely to achieve this competence. The main contribution of the first cycle students in the quality issue would be the partaking in the quality working groups and attendance in feedback practice.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

A prerequisite for comprehensive quality responsibility and quality concern is the ability to estimate the current situation, not only the quality of staff work (teaching practice), but more widely, the offered contents of general and subject related competences. At the beginning of studies the students are unlikely to achieve this competence. The main contribution of the first cycle students in the quality issue would be the partaking in the quality work groups and attendance in feedback practice.

COMPETENCE: Information management skills (Belgium)

What does this competence mean for your students?

Students have two types of information to manage:

- The information they receive through courses (lectures, practical work, and field trips).
- The information they have to find on a specific subject, usually as part of a personal work.

How do you help students to achieve this competence in your teaching methods?

Courses

- In every course the teacher insists on the most important concepts and paradigms about the subject. The teacher has to assist the students in making a hierarchy of the information being received.

Personal work

- The teacher gives some instructions to the students to organize information that they have collected. The instructions are provided as a help to the students to manage information.

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What learning activities do your students engage with in order to develop this competence?

Courses

- The students have to present for oral and/or written examinations during the academic year. The examinations help them learn what kind of information is of major or minor importance.

Personal work

- The students have to present oral and written reports about a specific subject. These reports will be the result of a bibliographical investigation. This subject is provided by the teacher in connection with his own courses.

How do you assess whether, or to what degree, they have achieved this competence?

Courses

- By an oral and/or written examination at the end of the academic year, at the end of the course, or after certain parts of the course. The examination does not concern only the theoretical part of the courses but also its practical part (laboratory, fieldwork).

Personal work

- The students have to present orally the results of a bibliographic 'bibliographical') investigation. After the presentation, the examiners will ask some questions and engage in a dialogue with the student in order to recognize whether he/she has a perfect understanding of the information collected by themselves. The same examiners evaluate the written report.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

Courses

- Students receive a mark after each examination. In some cases, they receive their written tests with annotation and remarks. These remarks help the student to understand whether his answer to the questions is correct or not. We hope that the remarks will help the student to improve his skill to manage the information he has to know.

Personal work

- Every student receives his written report with annotations and corrections. After the oral presentation of the report, every student will receive comments about the presentation. Mark is assigned for written report and oral presentation as well.

COMPETENCE: Oral and written communication in your native language (Spain)

What does this competence mean for your students?

It enables them to present their ideas and work in a clear and structured way.

How do you help students to achieve this competence in your teaching methods?

We offer some guidelines about the structure of written and oral presentations, and assist them when developing their reports in specific courses

What learning activities do your students engage with in order to develop this competence?

In many subjects written reports related to fieldwork or practical work at the laboratories are required. The oral aspects are only required in some (few) elective subjects, for some a poster is required. In some field camp students present their daily work to their classmates.At the end of the cycle they must present a tutelage final report about a specific matter of their studies (100 hours work is required).

How do you assess whether, or to what degree, they have achieved this competence?

The reports are evaluated during the semester. At the end of the cycle a guided report must be presented before finishing their studies, which is formally assessed.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

These presentations are marked, and literary skills are taken into account.

COMPETENCE: Ability to work in an interdisciplinary team (Scotland)

What does this competence mean for your students?

- Adapting to a problem-solving approach rather than a disciplinary problem: sensitivity, awareness and appreciation of the methods of other disciplines:
- Development of personal interactive skills
- Contribution to team objectives

How do you help students to achieve this competence in your teaching methods?

In a variety of learning settings, we set problems and ask questions but not simply the classical issues for a single discipline. We have questions such as: analyse the issues for the UK in developing long-term energy policy and the options open to it. Such questions require them to use their own disciplinary knowledge ranging from, on the one hand, assessment of the total hydrocarbon resource in the North Sea, and on the other the potential climatic consequence of burning it. The then need to become aware of other aspects of the problem: the technological possibilities of other sources or energy, the impacts on the national economy and regional employment of shifting energy generation modes; the degree to which scientific assessment of environmental consequence can be transmitted to the public and public reaction. There is only one knowledge set within a group of students working together, then the group tends to be driven by dominant ego or the most knowledgeable mind. When however the group contains different knowledge sets, students learn to appreciate the knowledge that others have and learn ways of incorporating diverge knowledge sets in their approaches. They also recognise that strengths are distributed in different ways. Some are good at orchestrating the debate, some are good at contributing ideas, and some are good at presenting. A not too dominant facilitator sitting on the edge of the group plays a very important role.

What learning activities do your students engage with in order to develop this competence?

- Field-based problems
- Technically based laboratory problems
- Activities Sustained over several weeks addressing single but wide-ranging questions

How do you assess whether, or to what degree, they have achieved this competence?

- Observation of the dynamics of the class working together;
- Through individually written reports that incorporate the findings of the whole class;
- Through oral presentation.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

- It is not a black and white digital phenomenon. Very few things are.
- Through oral feedback in individual tutorials
- Through written feedback on written work
- Most of all, students are individually aware without any comment from us about how much they have enjoyed the exercises and how much they have learnt from them.

COMPETENCE: Team work (Ireland)

What does this competence mean for your students?

This competence means a number of things, among which are:

- Ability to appreciate the significance of and integrate skill from different team members to solve a multi-faceted task
- Good teamwork is essential for good planning of field work
- Good teamwork is essential for the safe conduct of field work
- Teamwork can be used to enhance the educational experience beyond that supplied by the curriculum

How do you help students to achieve this competence in your teaching methods?

Formal

- Dividing tasks, such as preparing for a field trip, into elements and giving each team (class) member responsibility for an element. Students are then asked to 'lead' the appropriate section of the field trip.
- Field exercises are carried out in teams of two or more
- Safety training courses are offered for the whole class in which they must act as a team.
- Some practical exercises, particularly in earlier years are assigned to teams

Informal

- The Department supports and encourages student societies such as ROCSOC (geoscience related) and MARSOC(oceanographic and marine related)

What learning activities do your students engage with in order to develop this competence?

Students do the following:

- They have to decide how to break down a project into tasks for the team members
- They then have to perform these tasks
- They then have to integrate their results to produce the final product
- They are then given feed-back (often from other members of the team, rather than from staff) on their team performance.

How do you assess whether, or to what degree, they have achieved this competence?

- This is not formally assessed. Though some team efforts are marked as such and each member of the team obtains the same grade. The feed-back process is usually the best guide.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

- Through the feed-back discussions and meetings of individual groups with staff members to tackle problems and review progress

COMPETENCE: Ability to work in an international context (Holland)

What does this competence mean for your students?

Based on

1) the necessity to obtain experience abroad (considering the geological situation of the country),
2) the substantially international job market, and
3) the increasing international dimension of higher education, all students in Earth Science are in principle educated in a manner that should enable them to function in an international context, both in the course of their study and after completion.

For first cycle students this means:

- Getting acquainted with operating under practical and cultural circumstances that are different from the situation at home;
- Using almost completely foreign-language literature (95% English), including textbooks.

How do you help students to achieve this competence in your teaching methods?

- From the moment of entry on students have to study English-language textbooks. An annotated English-Dutch list of words (both general and technical terms) is provided with the initial textbook.
- Organising field activities abroad.
- Contributing to international activities of the students association
- First cycle students are encouraged to attend regular lectures by foreign scholars.

What learning activities do your students engage with in order to develop this competence?

- Field work and field trips in: Belgium, France, Britain, Spain etc. From the 1st year on responsibility for housing, transport etc. during summer fieldworks is largely put with the students.
- Studying almost completely foreign-language (English) literature.
- Occasionally: taking courses taught in English by non-Dutch staff.

How do you assess whether, or to what degree, they have achieved this competence?

- The studying of English-language literature is, implicitly, assessed continuously in the course of the general assessment procedures.
- Marking of field activities is, implicitly, connected to the performance in an international context.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

- Students are aware by self-assessment of the role of language problems in their performance. From the beginning they are aware that the ability to digest English-language literature is an absolute requirement.
- During in-course assessment during summer field work students are confronted with the negative impact of practical shortcomings in the international context (e.g. insufficient minimum command of language) on their performance.

A2.3. Subject Related Competences, Cycle 2

COMPETENCE: Ability to analyse the distribution and structure of a range of geological materials/phenomena (rocks, minerals, fossils, landforms, soils, fluids and gases) at all scales in both space and time (Finland)

What does this competence mean for your students?

- develops the ability to understand and identify the holistic nature of the subject

- develops the ability to assemble the learning outcomes from separate sources
- gives confidence to apply knowledge in practice, to collect and integrate several lines of evidence and formulate synthesis and modeling

How do you help students to achieve this competence in your teaching methods?

The core curriculum in geology has to be organized so that it has a sensible cover for geological and environmental conditions prevailing in my country. The education should expose the essential methodologies of the subject area. In geology this must contain field research and it has to direct the way how to use observations and records to make synthesis and models.

What learning activities do your students engage with in order to develop this competence?

They will participate in lectures, seminars and projects and make observations from field, collect field and laboratory evidence and use their records for synthesis and modelling.

How do you assess whether, or to what degree, they have achieved this competence?

This is an advanced competence which forms the base for an extensive set of skills, concepts, theories and methodologies which student has to attain, not only in geology, but in many other sciences. Assessing the degree by which the student has achieved this competence is possible to assemble by evaluating the student's advancements during the 2nd cycle program. Written presentations, maturity examination and mark of the thesis are appropriate for this target.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

Comments and a returned review of the student's written presentation, the discussions in seminars and in confidential meetings, self-assessments/assessment

COMPETENCE: Understanding of the main processes (physical, chemical and biological) which operate in and on the Earth and the integration of these processes (England)

What does this competence mean for your students?

- Emphasis on a process-oriented approach requires students to have a sound basis in mathematics, physics, chemistry and biology, and to be aware of the application of these to earth science by completion of 1st cycle.
- Process-oriented teaching is embedded in almost all the courses 2nd cycle students take, and is introduced fairly extensively in the 1st cycle.
- Students must also be aware of the need to consider processes operating over the wide scale ranges and timescales involved, which often negates direct experimental approaches.

How do you help students to achieve this competence in your teaching methods?

- Our students rarely enter university with proficiency in all of mathematics, physics, chemistry and biology, hence the need to provide early provision of courses in this area.
- We have also designed our courses to provide more advanced training in mathematics, physics and chemistry into the 2nd cycle.
- Training is provided in the understanding and use of numerical techniques and computer-based modelling codes.

What learning activities do your students engage with in order to develop this competence?

- Students require to have both a reductionist and holistic approach to earth processes. They need to simplify natural situations to a level where analytical, numerical or experimental models can be applied, whilst also appreciating the complex feedback systems which operate.
- Use of computer codes for simulation of earth processes.
- Comprehension, analysis and criticism of published research papers.

How do you assess whether, or to what degree, they have achieved this competence?

- Written exams are designed to test understanding of process rather than the ability to simply name, classify and order geological materials, structures and events.
- Completion of coursework exercises which involve the simulation of geological processes.
- Students are expected to read original research papers and their comprehension of these are tested.
- Oral and written presentation of work designed to investigate process.
- Students take 3-4 'advanced synthesis' modules, which are specifically designed to take students to the 'cutting-edge' of process oriented research and test their ability to synthesise geological observations and phenomena.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

- Through their performance in 'advanced synthesis' and other modules.
- In the end, a process oriented approach provides a better framework within which to classify, order and understand geological observations, and hence impacts on all their work and examinations.

COMPETENCE: Understanding the quality of Earth Science related research (Netherlands)

What does this competence mean for your students?

It is imperative that Second Cycle students are ableto judge the quality of published or otherwise communicated research. They are dependant on this especially for their MSc thesis work and in practice after completion of studies.

How do you help students to achieve this competence in your teaching methods?

- In seminars and specialized courses (see below)
- Through guiding MSc thesis preparation
- By confronting students in the field with researchers and research results

What learning activities do your students engage with in order to develop this competence?

- Staff comments in "state of the art" specialized courses on the significance of recently communicated research results;
- In seminars publications, studied beforehand by students, are critically reviewed;
- In one to one discussions related to thesis preparation the quality and significance of published data is discussed with students;
- Students are confronted in the field (and in classes), but also through international exchange, with the personalities behind published research and with the research environment, both in the field and in the institute/laboratory.

How do you assess whether, or to what degree, they have achieved this competence?

This is, formally, primarily assessed by judging the MSc thesis, although staff will mostly have already a good impression of students' abilities in this respect.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

By feedback on seminar contributions and MSc thesis drafts and by marking and commenting upon field courses

COMPETENCE: Competence: Collecting, recording and analysing data using appropriate techniques in the field and laboratory (Belgium)

What does this competence mean for your students?

Students must be able to collect and identify field samples correctly and to manage petrological, geochemical, and mineralogical analyses.

How do you help students to achieve this competence in your teaching methods?

Students are trained in collecting and identifying samples during fieldtrips and practical work. In the same way analyses capabilities occur during practical and laboratory work. More specific aspects are gained during the final thesis of the cycle, the student being incorporated within a research team

What learning activities do your students engage with in order to develop this competence?

Fieldtrips and practical work are specially scheduled so as to get this competence during the 2nd cycle.

How do you assess whether, or to what degree, they have achieved this competence?

Fieldtrips and practical work are evaluated through reports and examinations during the courses, and at the end of the courses. This competence is also evaluated through the final thesis being presented at the end of the cycle.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

Fieldtrips and practical work are marked.

Should the student not be able to achieve the requested competence with respect to the final thesis, this one shall not be approved by the jury.

COMPETENCE: Undertaking field and laboratory investigations in a responsible and safe manner, paying due attention to risk assessment, rights of access, relevant health and safety regulations, and sensitivity to the impact of investigations on the environment and stakeholders (Spain)

What does this competence mean for your students?

It provides training in responsible behaviour, both as a citizen and as a future scientist, with regard to the natural and societal environment, but also concerning personal well-being.

How do you help students to achieve this competence in your teaching methods?

By confronting them with the practical and social limitations of carrying out field research and the safety measures to be taken into consideration in both laboratory and field work.

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What learning activities do your students engage with in order to develop this competence?

The Faculty has published detailed regulations concerning field research (always two students together, always asking permission to enter private property, wearing helmets, not throwing away chemicals, etc.). During laboratory courses students first are instructed on safety regulations.

In addition we offer a short course, which is not mandatory, but in effect is, on "Safety in the mountains". This course is given by official mountain instructors of the "Mountain School" of the "Centre Excuresionista de Catalunya" during the first year, before beginning any field work.

How do you assess whether, or to what degree, they have achieved this competence?

Assessment during both field and laboratory courses, with feedback to the students.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

The assessment should make students well aware of their behaviour. This is not always a guarantee that this behaviour conforms to the Faculty's standards.

COMPETENCE: Preparing, processing, interpreting and presenting data, using appropriate qualitative and quantitative techniques and packages (Ireland)

What does this competence mean for your students?

- The ability to prepare a thesis
- The ability to get a job

How do you help students to achieve this competence in your teaching methods?

- The department runs a formal series of seminars given by staff competent in display, analytical or modelling software.

- The University provides basic computer literacy courses and courses in specialised areas such as GIS
- Every student has access to an individual PC
- Perhaps more staff time is spent in assisting students with this aspect of their training than any other.
- Perhaps more student-student contact is generated by this aspect of their studies than any other. There is usually one student seen as 'the expert' to whom all others defer.

What learning activities do your students engage with in order to develop this competence?

Students do the following:

- Students collect and process their own data. They are encouraged to start in the field and not to put it off until returning to the laboratory.
- Students often help others, less experienced. They learn a lot by doing this.
- Regular training sessions, often in small groups, with their supervisor or with a member of the technical or academic staff familiar with the software.

How do you assess whether, or to what degree, they have achieved this competence?

- This is assessed in marking the student thesis and, in the case of taught masters, by students completing an analysis of a supplied data-set.
- All *Cycle 2* students receive a viva voce examination with an external examiner before award of their degree. This constitutes a formal part of the exam.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

- This is difficult to assess as one can nowadays produce professional results from poorly managed or quality controlled data. The viva voce examination is important in this regard.
- Students are given a formal debriefing after their viva voce exams and told what their final grade was and how the various competences contributed to this grade.

- Private briefings with supervisors and public discussion after presentations
- Criticism by staff members of first draft manuscripts
- Criticisms by external referees where manuscripts have been submitted for publication.

COMPETENCE: Appreciating issues of sample selection, accuracy, precision and uncertainty during collection, recording and analysis of data in the field and the laboratory (Scotland)

What does this competence mean for your students?

Earth Science is an empirically based science. These competencies are absolutely fundamental and are the roots of our science. It is vitally important that second cycle students understand this as errors of observation their stochastic treatment in analysis are crucial in Earth Science. It is the corner stone of any rigorous master's programme.

How do you help students to achieve this competence in your teaching methods?

Primarily through specific examples, both formally introduced in teaching sessions and as an integral part of individual projects and the final master's thesis work.

What learning activities do your students engage with in order to develop this competence?

- Issues are formally introduced in lectures
- They are a basic part of project work, either in the field or laboratory
- They are embedded in individual student theses.

How do you assess whether, or to what degree, they have achieved this competence?

- Written and oral work

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

- Feedback in written and/oral form.

A2.4. Subject Related Competences, Cycle 1

COMPETENCE: : Ability to analyse the distribution and structure of a range of geological materials/phenomena (rocks, minerals, fossils, landforms, soils, fluids and gases) at all scales in both space and time (Norway)

What does this competence mean for your students?

This competence means for the 1stcycle students that they understand the variety of materials and phenomena in geology and understand the appropriate techniques to use. They should also be able to put this in a space- and time frame.

How do you help students to achieve this competence in your teaching methods?

This competence is particularly achieved by the use of practicals, excursions and field work.

What learning activities do your students engage with in order to develop this competence?

This competence is particularly achieved by the use of practicals, excursions and field work.

How do you assess whether, or to what degree, they have achieved this competence?

By giving tests at practicals and requiring reports from field courses in addition to examinations.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

By discussions during fieldwork and practicals.

COMPETENCE: Grounding in the basic knowledge of the Profession (Spain)

What does this competence mean for your students?

To learn in what fields they can work when they finish.

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How do you help students to achieve this competence in your teaching methods?

For the compulsory basic courses teachers state explicitly which activities are very useful for the Profession (recognition of rocks and minerals, mapping…). We advise them when they ask.

What learning activities do your students engage with in order to develop this competence?

a) For the beginners, a set of optional 1hour monthly seminars related to varied geology fields, including Professional fields, called "A taste of Geology".

b) A one-day workshop where different geologists come to explain their personal experiences in the professional work. This include people from private companies, administration agencies, non governmental organizations…This is organized by a group of five students and one teacher and performed during the last semester of the cycle, for third and fourth year students.

c) When the students have more than 50% of the credits they can follow a programme of industrial placements in companies and institutions by means of cooperative and educational agreements. This is done by almost 90% of the students for a placement of 300 hours.

d) A labour exchange is maintained on the centre website; this also include a virtual place where students, that have finished, can send their CV.

e) A graduate ceremony is held once a year where a member of the Spanish official association of professional geologists explains this association.

How do you assess whether, or to what degree, they have achieved this competence?

For the industrial placements a positive report from them is required in order to give some credits

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

There is no formal evaluation

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COMPETENCE: Competence: Ability to integrate field and laboratory evidence with theory following the sequence from observation to recognition, synthesis and modelling (Ireland)

What does this competence mean for your students?

- This does not mean a lot a lot in earlier years. One of the great problems we face is to get students to transfer knowledge from one field or method to another. The exam system has forced them to separate all disciplines into little boxes to be learned, regurgitated and then discarded.
- In later years it is the thing they find most satisfying about geology.

How do you help students to achieve this competence in your teaching methods?

- In first year (we have a 4 year *cycle 1* degree), the students practical exercises are integrated with the lectures and usually involve using the web or commercial software as well as the specimens to solve problems. Field experience is limited because of numbers (~150).
- 2nd, 3rd and 4th year field trips provide excellent opportunities for integration all types of data, but less so for modelling
- Project work is the best method for developing such competence. Final year students do two projects. A compulsory field based (traditional) mapping project of 6 weeks fieldwork involving geology, geophysics, hydrogeology or oceanography, plus preparation of a thesis and give a formal 15 minute talk. The other project is allocated 80 hours and is intended to be an introduction to the workplace where students prepare and cost a consultancy report on a given topic including and executive summary, web page and a short talk.

What learning activities do your students engage with in order to develop this competence?

Students do the following:

- They have a series of seminars, plus formal meeting with supervisors to ensure that data collection, integration and modelling is performed in a satisfactory manner.
- They attend a series of lectures given by outside experts which synthesize an area of the discipline

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- They are encouraged to attend the Irish Geological Research Meeting where post-graduates give many of the talks.
- We run a series of internal lunch-time post-graduate seminars which are attended by 3rd and 4th year students.
- Preparation of thesis and field reports

How do you assess whether, or to what degree, they have achieved this competence?

Projects are formally assessed and can comprise up to 33% of the final year mark.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

- All projects involve presentations given in front of the class where feed-back from both class members and staff is given. This is done before the formal submission of the project to allow time for feed-back to be incorporated.
- Meetings with supervisors also give feed-back.
- The final exam mark reflects the success of such integration.
- The University sets aside a day where students can discuss exam performance with relevant staff.

COMPETENCE: Recognising and using theories, paradigms, concepts and principles that are specific to Earth Science (Scotland)

What does this competence mean for your students?

- Changing the ideas that they have frequently come with from school, that science is about certainty. Knowledge is handed down to them as students in a finished form;
- Recognising that science is about uncertainty, that much of the time we are concerned to map the boundary of that uncertainty, and frequently change the pattern of understanding in a fundamental way
- Understanding why Richard Feynman was right "Science is about making a guess, and then going to find out whether the guess was right".

- Theories etc are simple reflections of the assumptions and perspectives we start from in launching our guesses
- Having them recognise that science is not just a hand-me-down, it is something that is done by an individual, including them.

How do you help students to achieve this competence in your teaching methods?

By ensuring that the above perspectives and principals, scepticism, reflection and personal engagement are embedded in the teaching and learning programme and made specific to Earth Science Studies

What learning activities do your students engage with in order to develop this competence?

Lectures, practical, field trips, seminars/tutorials, are the basis of all our understanding in uncertain theory, deriving from the work of individuals and groups, is drawn attention to. The final year programme contains a major course titled "Earth evolution". It is highly synthetic bringing together much knowledge and understanding that has been developed and with the assertion that our understanding is theoretically based. Certain things, (volcanoes, glaciers) are visible and identifiable entities, other things (tectonic plates, plumes) are post-hoc logical constructs, and may prove to be transient.

How do you assess whether, or to what degree, they have achieved this competence?

- Through essays designed to test this competence;
- Through seminar and tutorial discussions
- Through field discussions
- Through oral presentations and project work
- Through presentation of an undergraduate thesis

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

- Through written feedback on essays, reports
- Through oral feedback at the time of presentation, and in tutorials.

COMPETENCE: Recognising the moral and ethical issues of investigations and appreciating the need for intellectual integrity and for professional codes of conduct (Belgium)

What does this competence mean for your students?

Students in the 1st cycle are not always aware of the importance of this competence.

How do you help students to achieve this competence in your teaching methods?

We try to show them how to be rigorous and honest in their work during their studies. If they gain intellectual integrity as a student, we hope that they will keep integrity in their professional life.

Visiting company geologists explain to the students the importance of the moral and ethical issues of investigations. Some teachers will also insist on this topic during fieldtrips.

What learning activities do your students engage with in order to develop this competence?

Until now, we do not have any specific learning activities about this competence during the 1st cycle. We are introducing this competence during the 2nd cycle.

With the introduction of the 3+2 cycle in September 2004 (instead of 2+2 now), we will have to rethink how to introduce this subject specific competence during the 1st cycle.

The professional code of conduct is distributed by the national association of professional geologists. The graduates will receive this code when requesting a membership from the association.

How do you assess whether, or to what degree, they have achieved this competence?

We currently have no formal learning activity associated with this competence.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

We currently have no formal learning activity associated with this competence.

COMPETENCE: Planning, organising and conducting, and reporting on investigations, including the use of secondary data. (Finland).

What does this competence mean for your students?

- To receive this competence a first year student has to familiarize themselves with problem solving techniques, think about the methods of investigation and how to manage the survey.
- Making a synthesis from an investigation encourages the student to utilize the skills and competences, which she or he has received during the1st cycle studies.
- Reporting helps the student develop written communication skills, use subject-specific data and to distinguish primary evidence from secondary interpretations.

How do you help students to achieve this competence in your teaching methods?

- Lectures on this issue, examples are given on how to organise an investigation, discussion takes place about the common problems in investigation work etc.
- Exercises with pre-prepared data. This would include some usage of statistical software.
- Presentations (written + oral), which requires a bibliographic search in library and on the internet.

What learning activities do your students engage with in order to develop this competence?

The basic knowledge of subject area must first have been acquired from lectures, exercises and presentations. For most of the students the skill of written communication requires practice. Planning the investigation, handling the data and making synthesis of the data can be learned i.e. in seminars, field courses or in practical training.

How do you assess whether, or to what degree, they have achieved this competence?

Marking the report highlights problems in planning or in the understanding of the problem.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

The student has to produce a summary report, which is discussed either in a private meeting or alternatively in a group (peer assessment). The final report is marked and commented.

COMPETENCE: Collecting, recording and analysing data using appropriate techniques in the field and laboratory (England)

What does this competence mean for your students?

- Taking responsibility for the collection of their own field notes and records of observations in laboratory classes.
- Becoming familiar with a wide range of methods of data collection.
- Providing regular summaries and analysis of observations. In the field this involves daily summaries of observations.

How do you help students to achieve this competence in your teaching methods?

- Introduction of laboratory sessions and field classes at an early stage, with the structured development of these throughout the curriculum.
- Clear definitions of aims and objectives of field and laboratory sessions. I usually set a clear aim each day and develop a set of specific objectives from this. In laboratory sessions these tend to be fairly tightly constrained. In the field, I encourage discussion of objectives at the start of each day and develop these at individual localities.
- The analysis of data provides students with a good indication of the adequacy of their data collection. Practical constraints (time, available material, etc) often lead to students acquiring insufficient or inadequate data, this needs to be discussed and a rationale for adequate data collection developed.

What learning activities do your students engage with in order to develop this competence?

- Students learn to work independently and in small groups.
- A wide range of methods of data collection need to be learnt, including the use of appropriate techniques and equipment. In the 1st cy-

cle, this does not usually involve any complex analytical equipment, but would include some simple field equipment, including geophysical equipment.

- In both the field and laboratory, students learn to set up aims, to convert these into objectives, to set up hypotheses, and develop strategies of data collection to test these.
- Students are encouraged to question both their objectives and methodology and to discuss these with academic staff (including Graduate Teaching Assistants).

How do you assess whether, or to what degree, they have achieved this competence?

- Regular assessment of laboratory and field notebooks.
- Follow-up exercises involving the analysis of the student's own data, pooling data from several students where appropriate.
- The assessment of field and laboratory course should include opportunities for students to present their own data and its interpretation.

How do your students know whether or to what degree they have achieved this competence, and if not, why they have not achieved it?

- Inclusion of independent exercises involving collection, analysis and summary of data.
- Feedback based on laboratory and field notebooks is an essential part of the process of developing this competence and keeping students informed of their progress.
- All our students are expected to undertake a 5-week independent mapping project as part of their 1st cycle. This is an excellent test of their competence to collect, record and analyse data. They prepare a substantial report based on this.

ANNEX 3: Example of a Workload Calculation

A3.1. To be completed by the Teacher

Tuning
Tuning Educational Structures in Europe

PLANNING FORM FOR AN EDUCATIONAL MODULE ©

(to be completed by the teacher)

Programme of Studies: Earth Science Honours Degree, 3rd year of a 4 year B.Sc.
Name of the module / course unit: Field mapping of solid geology and surficial deposits
Type of course (e.g. major, minor, elective): major
Level of the module / course unit (e.g. BA, MA, PhD): Bachelors
Prerequisites: GE200 (2nd year Geology)
Number of ECTS credits: 10

Generic Competences to be developed[2]**:**

- Capacity for analyses and synthesis
- Capacity for organisation and planning
- Information management skills (ability to retrieve and analyse information from different sources)
- Problem solving
- Decision-making
- Teamwork
- Interpersonal skills

2 A considerable number of competences, both specific and generic, are developed during intensive field work classes where the students are working on their own or in small groups. This is because they are holistic and encourage the student to integrate much of the theoretical and practical material absorbed in the class and through reading to solve a real world problem. The example used here is for a basic geological mapping course. A geophysical survey, environmental or hydro-geological mapping or a short oceanographic cruise would develop a similar variety of competences.

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- Capacity for applying knowledge in practice
- Research skills
- Capacity to learn
- Capacity to adapt to new situations
- Capacity for generating new ideas (creativity)
- Capacity to deliver results when working in a different environment

Specific Competences to be developed:

- The ability to accurately record field data using a variety of techniques
- Preparation and maintenance of field notebooks, field slips
- The use of IT aids in the field
- The preparation of reports and interpretive maps using appropriate IT and manual techniques
- A concern for field safety
- A respect for the rights of land owners and users
- The techniques for collection and subsequent laboratory analysis of field samples
- The ability to link outcrop data into a four dimensional model describing the geological evolution of the region
- The preparation of maps, sections and diagrams to illustrate this 4D analysis
- An appreciation of the environmental and commercial aspects of the material mapped

A3.2. Teacher's estimate of workload

Learning outcomes	Educational activities	Estimated student work time in hours	Assessment
Introduction to field safety: The ability to plan and execute a safe day's work in the field.	2 hours Lecture and 2 day field exercise with optional CPR and 1st Aid courses	22-40	Continuous: by qualified safety instructors. No formal mark, but certificates awarded to all who pass.
Field course: The ability to collect earth science data in the field, to analyse and archive this data.	7 days supervised field work. First two days working in groups closely supervised by lecturers who define the task to be completed. Four days working semi-independently in small groups (2-4 persons) and one day site visit to a slate quarry.	100 hours 8-10 hours each day in the field and up to 3 hours each evening 'mapping in' (analysing, consolidating and plotting data collected that day). Travel time: home to/from locality – 2 days	Continuous assessment: = 50% of total
Preparation of short report on data collected in the field. The ability to concisely integrate and summarise earth science data collected in the field. The ability to prepare and understand geological maps.	Working in a small group (2-4 persons) back in laboratory: describing material collected; preparing neat copy maps, plans, diagrams and cross sections; preparing a concise report on stratigraphy; structure; surficial deposits; economic potential and environmental aspects of area studied.	100 hours	Submission of project by a deadline, which is then marked. = 50% of total.

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A3.3. To be completed by the Student

FORM FOR CHECKING WORKLOAD OF AN EDUCATIONAL MODULE ©   **(to be completed by the student)**

Programme of Studies: Earth Science Honours Degree, 3rd year of a 4 year B.Sc.
Name of the module / course unit: Field mapping of solid geology and surficial deposits
Type of course (e.g. major, minor, elective): major
Level of the module / course unit (e.g. BA, MA, PhD): Bachelors
Prerequisites: GE200 (2nd year Geology)
Number of ECTS credits: 10

Generic Competences to be developed:

- Capacity for analyses and synthesis
- Capacity for organisation and planning
- Information management skills (ability to retrieve and analyse information from different sources)
- Problem solving
- Decision-making
- Teamwork
- Interpersonal skills
- Capacity for applying knowledge in practice
- Research skills
- Capacity to learn
- Capacity to adapt to new situations
- Capacity for generating new ideas (creativity)
- Capacity to deliver results when working in a different environment

Specific Competences to be developed:

- The ability to accurately record field data using a variety of techniques
- Preparation and maintenance of field notebooks, field slips
- The use of IT aids in the field
- The preparation of reports and interpretive maps using appropriate IT and manual techniques
- A concern for field safety
- A respect for the rights of land owners and users

- Collection and subsequent laboratory analysis of field samples
- The ability to link outcrop data into a four dimensional model describing the geological evolution of the region
- The preparation of maps, sections and diagrams to illustrate this 4D analysis
- An appreciation of the environmental and commercial aspects of the material mapped

A3.4. To be completed by the Student

Learning outcomes	Educational activities	Estimated student work time in hours	Assessment
Introduction to field safety: The ability to plan and execute a safe day's work in the field.	2 hours Lecture and 2 day field exercise with optional CPR and 1st Aid courses	Include time spent in class, under instruction, time rehearsing skills before assessment, time spent in assessment and debriefing. HOURS=	Continuous: by qualified safety instructors. No formal mark, but certificates awarded to all who pass.
Field course: The ability to collect earth science data in the field, to analyse and archive this data.	7 days supervised field work. First two days working in groups closely supervised by lecturers who define the task to be completed. Four days working semi-independently in small groups (2-4 persons) and one day site visit to a slate quarry.	Include time spent in field, travel time to and from locality each day, time spent each evening 'mapping in', and travel time between University and field course locality. HOURS=	Continuous assessment: = 50% of total

Learning outcomes	Educational activities	Estimated student work time in hours	Assessment
Preparation of short report on data collected in the field. The ability to concisely integrate and summarise earth science data collected in the field. The ability to prepare and understand geological maps.	Working in a small group (2-4 persons) back in laboratory: describing material collected; preparing neat copy maps, plans, diagrams and cross sections; preparing a concise report on stratigraphy; structure; surficial deposits; economic potential and environmental aspects of area studied.	Include all time spent working on samples, preparing maps, figures and report. Plus time discussing report with supervisor and preparing various revisions. HOURS=	Submission of project by a deadline, which is then marked. = 50% of total.

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CONTACT US

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Visit the Tuning website for more information at **http://tuning.unideusto.org/tuningeu** and **www.rug.nl/let/tuningeu**

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