EDUCATION RELATED TO MINERAL RAW MATERIALS IN THE EUROPEAN UNION

DEVELOPMENT OF DRAFT SYLLABI FOR UNIVERSITY EDUCATION AND BLUEPRINTS FOR INDUSTRY TRAINING AND COURSES FOR GEOLOGICAL SURVEYS

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CONTENTS

1 INTRODUCTION

The Strategic Implementation Plan for the European Innovation Partnership on Raw Materials, Part I (2013) as well as many mineral strategies on EU Member State national levels (Defra report 2012) have identified skill issues as a prioritised area. The COBALT project addresses skill, knowledge and competence issues related to mineral raw materials by a three-step approach:(i) surveying of existing educational offers and identification of skill shortages, (ii) planning of schemes for their mitigation and finally (iii) testing and evaluation.

The first part of the project assumed a matrix approach in the mapping of mineral resource-related educational offers within the European Union (Sand, Rosenkranz 2014a). Differences were surveyed both by taking a geographic perspective and also a cross-value chain approach. The geographic perspective included linking between industrial activity and access to education on national and regional level within the EU, while the value chain approach included mapping the availability of education within various relevant raw material-related value chain constituents. These included disciplines such as applied geology, mining, mineral processing, metallurgy, recycling and mining-related environmental engineering. Furthermore, the educational depth was evaluated by analysing course offers and ranking the level of each educational programme based on the categories; single courses, Bachelor, Master or third-cycle education.

In this report the identified skill shortages during the mapping phase are briefly summarised and some of these issues are later addressed by proposing educational schemes for their mitigation on various levels, including short course, block course and full study programme development. The structures listed in this report thus constitute recommendations for working plans based on key observations as discussed in the first project report.

2 SUMMARY OF SKILL SHORTAGES AND MITIGATION SCHEMES

The first report of the project was concluded with a discussion of several different approaches for addressing some of the identified skill shortages. Development of full study programmes, short courses or block courses were presented as possible mitigation schemes, depending on region, contents to be covered and intended target audience. Each of these schemes is briefly discussed below.

Transformational curricula, here defined as educational programmes for students of other background or BSc degrees that enable them to gain proficiency in a mineral raw material-related subject, has previously been lifted as fast-track schemes. As this concept has recently been tested and evaluated in a relevant region within the European Union (Ahonen and Heiskanen 2012), this approach was not further explored within this report. The concept has been summarised and discussed in the previous report (Sand, Rosenkranz 2014a).

2.1 SHORT COURSES

Within the first report (Sand, Rosenkranz 2014a), the need for generalist introductory courses to respond to skill shortages within stakeholder groups with limited technical background competences, such as policymakers and civil society organisations, was discussed. This need has also been acknowledged by other European expert networks such as ERA-MIN (Vidal et al. 2013). Within this part of the project, a two-day short course was designed to meet this challenge. The course is structured in a way that it gives participants an introduction to the various processes within the mineral raw material value chain, as well as discussing a number of related key topics. These include, for instance, environmental considerations in minerals and metals production, mine closure and reclamation activities.

2.2 BLOCK MODULE COURSE

Several regions within the European Union were found to have limited study offers related to sustainable mineral and metal production and recycling processes. Within this report a block course is presented that has been developed for addressing this issue. The target audience is intended to be either professionals already working in industry or BSc level university students. The course can thus be considered as either a specialist training course or a blueprint for a block course possible to embed in a relevant university-level educational programme.

2.3 FULL STUDY PROGRAMME

During the mapping of educational offers and evaluation of the regional importance of the mineral resource industry, Greenland was identified as a country with strong geological potential and is expected to emerge as an important future mining region. This case was therefore selected as being interesting to work on in the COBALT project.

The access to academic level education in the raw materials sector in Greenland is limited. Furthermore, Greenland is also due to its small population base not expected to be able to supply the mining sector with a sufficiently large workforce, should mining activities start to expand as indicated by some projections (Nielsen 2013). The challenge is thus twofold: at first, to provide educational opportunities to the Greenlandic population, secondly, to also construct a relevant academic programme giving students from outside the region the appropriate skill set to work in Arctic conditions. The current limitations in access to labour force bear the risk of posing a serious restriction on the implementation of mining projects in the region. As for instance discussed in the EIP Strategic Implementation Plan on Raw Materials (2013), it is of high strategic importance for the EU to reduce import dependency and to secure raw material supply from European sources. Albeit the special OCT-status of Greenland (Loukacheva 2007), the Arctic region and Greenland in particular will likely play an important role in diversifying the raw material supply to the EU. This translates into a need for a European-based educational programme devoted to the raw materials sector in the Arctic region, enabling the education of not only the local population but also other nationalities interested to work in Greenland or other parts of the Arctic.

3 DEVELOPMENT OF STUDY OFFERS

3.1 SHORT COURSE: INTRODUCTION TO MINERALS AND METAL PRODUCTION"

3.1.1 Introduction

The discussion of technical aspects of mineral and metal production among non-experts or between specialists and non-experts is typically hampered by the differences in information level and terminology. This, for instance, results in misled interpretations of environmental risks from processing or in unrealistic expectations about technical feasibility of what is technically feasible when it comes to recoveries from primary production or metal recycling.

This situation can be overcome by educating lay persons in order to fill the knowledge gaps in process technology and by conveying general awareness of existing technical constraints with regard to both material and process. Interdependencies between the individual processing steps make it necessary to take a more holistic view on the entire value chain of mineral and metal production.

A course that meets this challenge therefore has to be broad enough, so that it covers the steps of extraction, ore dressing and refining. The level of detail in describing complex technical coherences on the other hand needs to be limited in order to meet the expectable level of prior knowledge of the target audience and for not going beyond the scope of the course. Lectures should be given in a popular science way, in order to meet the needs of the non-technical target audience.

This type of course could be offered in collaboration with public agencies, e.g. geological surveys, as potential mentoring institutions. Compared to courses given in academic education the language will most probably be an issue. Thus, based on the original English version the course should be translated into the local language for implementation.

3.1.2 Target audience

The developed short course "Introduction to minerals and metal production" is intended for a broad target audience: policy makers, representatives from consumer organisations, members of non-governmental organisations and other stakeholders from civil society that are not familiar with the technical background of minerals and metal production and want to improve their knowledge in this field.

There are no formal prerequisites that the participants need to fulfil. The course is designed for anyone that is interested in this field, be it in the professional or personal context.

3.1.3 Course aim and expected outcome

The course aims at providing a common understanding of mineral and metal production under a holistic value chain perspective and by considering the different periods of time of a mine's life cycle.

Intended learning outcomes: After completion of the course the participants should be able to:

- Describe different mineral resources (ore types, occurring minerals)
- Explain the different steps in developing a mine project
- Describe the major unit operations that are used within ore dressing and metal extraction
- Discuss the environmental, social and economic dimensions of sustainable mineral and metal production

3.1.4 Course content

Lectures will be given in the areas of:

1. Ore geology and mineralogy (emphasis depending on location): ore formation, occurrence of metal-bearing minerals, selected applications
2. Mineral exploration and mining project development: legal framework, exploration methods, mineral economics, feasibility studies
3. Mining methods: production technology in underground mining, open pit mining
4. Mineral processing: principles of ore dressing, selected unit operations and processing flow sheets
5. Metallurgical processing: principles of metal production, selected processing flow sheets
6. Environmental aspects of mine production: waste rock and tailings, energy use, air and water emissions
7. Mine closure and reclamation
8. Metal recycling from residues and end-of-life products

Workshops and panel discussions will be dedicated to:

- Resource management in the EU: demand and supply
- Impacts from mining operations: economic-environmental-social
- Sustainable metal production
- Environmental aspects of mining – the long-term perspective

3.1.5 Realisation

The short course will be held as a 2-day seminar. Teaching comprises in total 8 lectures (duration 1 hour each, followed by 15 minutes for questions and answers) as well as 3 interactive workshop formats for initiating discussion and contemplation after every second lecture (duration 1 hour each with 15 minutes wrap-up).

The course concludes with a panel discussion exercise of 1 hour on the second day where the course participants are requested to take up the position of other stakeholder groups within a certain topic area, also with 15 minutes wrap-up and final conclusions. A draft schedule for the course is summarised in Table 1.

Table 1. Course schedule

Time	Duration	1. Day	2. Day
08.00 – 10.30	1:00 h	LECTURE1 Ore geology and mineralogy	LECTURE 5 Metallurgical processing
	0:15 h	Q/A	Q/A
	1:00 h	LECTURE 2 Mineral exploration and mining project	LECTURE 6 Environmental aspects of mine production
	0:15 h	Q/A	Q/A
	0:15 h	Break	
10.45 – 12.00	1:00 h	WORKSHOP 1 Resource management in the EU	WORKSHOP 3 Sustainable metal production
	0:15 h	Wrap-up	Wrap-up
	1:00 h	Break	
13.00 – 15.30	1:00 h	LECTURE 3 Mining methods	LECTURE 7 Mine closure and reclamation
	0:15 h	Q/A	Q/A
	1:00 h	LECTURE 4 Mineral processing	LECTURE 8 Metal recycling
	0:15 h	Q/A	Q/A
	0:15 h	Break	
15.45 – 17.00	1:00 h	WORKSHOP 2 Impacts from mining operations	PANEL DISCUSSION Environmental aspects of mining – the long-term perspective
	0:15 h	Wrap-up	Wrap-up, closure

3.1.6 Course literature

In this introduction-type course there will not be any course books assigned. Hand-outs of the presentation material will be provided by the course authors.

3.1.7 Course evaluation

Course evaluation will be conducted at the end of the course based on a printed questionnaire. The results of this questionnaire will constitute part of the basis for analysing the outcomes of the pilot testing phase in the final report of the project (also see the discussion in chapter 4).

3.2 BLOCK MODULE COURSE: "SUSTAINABLE MINERALS AND METAL PRODUCTION"

3.2.1 Introduction

Some EU Member States where mining and metal production is taking place do not offer suitable study programmes (Sand, Rosenkranz 2014a). Furthermore, in EU Member States where such mining-related engineering programmes exist, the number of vacant positions in industry cannot be filled by local graduates (Sand, Rosenkranz 2014a).

In addition to hiring personnel from abroad companies often choose the option of employing engineers with a different background, for instance in process engineering or chemical engineering. As some studies have pointed out, this is not necessarily a drawback since these professionals provide alternative skill sets to the industry (McDivitt 2002). However, in order to improve process understanding and alleviate communication with other parts of the workforce, there is a need for time-condensed training schemes. This would allow engineers with other background to level up their competences with respect to understanding the characteristics of natural mineral resources and the particular process technology used for ore dressing and refining.

Besides various on-site opportunities offered by the company such as "training-on-the-job" type apprentice systems, there is also a need for more formalised approaches. This can for instance include either specialised courses giving an overview on relevant process technology to young professionals, or even specified training related to a particular process.

Depending on the number of participants and the availability of laboratory facilities for conducting the necessary practical exercises in an engineering course, training can be flexibly provided either in the form of university courses or as specialist training at the facilities of the mining company.

As previously mentioned, a course that addresses participants in preparation to, or already working in industry, will be subject to time restrictions. The setup of this type of specialist course should therefore consider that it is often not possible to teach a course over a long time period like a university term. Instead a block module course taught intensively over a time frame of maximum a few weeks should be the preferred format.

Potential mentoring institutions to be attached for conducting such a block module course could include one or several local universities within the region of interest, which have own expertise within the field of mineral and metallurgical processing.

3.2.2 Target audience

The block module course "Sustainable minerals and metal production" is intended for persons with at least a Bachelor level degree in engineering. This could for instance include graduates of a process, chemical or mechanical engineering programme, who either have plans to work or are already actively working in the minerals and metallurgical industry or need to build up or improve their competences in the field of minerals beneficiation and metal extraction including recycling processes.

The educational level of the course is of advanced level (second cycle, after completion of a bachelor) (The Bologna Declaration 1999).

The course is taught in English.

3.2.3 Entry requirements, specific entry

General entry requirements for the second cycle apply:

A Bachelor or 3 years of studies in a relevant engineering field or with equivalent knowledge from practical work experience (minimum 5 years work experience for instance as a process or development engineer) is required for entering the course.

Documented skills in English language.

3.2.4 Course aim and expected outcome

The course aims at providing knowledge on mineral and metallurgical processing of metal ores and metal recycling.

Intended learning outcomes: After completion of the course the student should be able to:

- Describe the concept of sustainable development
- Describe different types of metal ores and their mineralogy
- Describe and explain the unit operations and flow sheets used in metal ore dressing
- Understand different metallurgical unit processes and their specific reaction processes
- Describe and explain material and energy flows related to extraction of metals and alloys
- Understand the life cycle of metals
- Describe and explain the techniques usually used in recycling
- Describe the important limitations for recycling

3.2.5 Course content

Lectures will be given in the areas:

1. Introduction: metal life cycle, design for recycling
2. Mineral processing
3. Metallurgical processing
4. Metal recycling – Pre-treatment
5. Metal recycling – Metallurgical processing

Laboratory exercises will comprise:

- Comminution tests
- Separation tests
- Smelting experiment and mass balancing
- Leaching experiment

Exercises will cover

- Calculation of grades/recovery/selectivity
- Material balancing for a concentrator
- Technical-economic analysis of process alternatives
- Simulation of a copper converter

3.2.6 Realisation

The course is taught in a block module of 2 weeks. Alternatively the programme can be divided into five separate 2-daymeeting blocks, if required by the companies' operational constraints. The latter concept has proven to be easy to combine with industry needs (Lindberg et al. 2013). Teaching comprises in total 16 lectures (duration 1.5 hours each) as well as written assignments. Table 2 and 3 both show the blueprint of the course schedule.

Table 2. Course schedule week 1: Focus – Mineral processing

1. Day	2. Day	3. Day	4. Day	5. Day
1. Introduction	4. Comminution	7. Other sulphide ores dressing	Lab exercise comminution	Lab exercise separation
2. Geology	5. Flotation	8. Gravity sep.	Lab exercise comminution	Lab exercise separation
3. Mineralogy	6. Copper ore dressing	9. Magnetic sep.	10. Iron ores dressing	Ex. Process data evaluation
Ex. Grades/selectivity	Ex. Balancing	Ex. Separation curves	11. Precious metal ore dressing	

Table 3. Course schedule week 2: Focus – Metallurgical processing and recycling

6. Day	7. Day	8. Day	9. Day	10. Day

12. Pyrometallurgy	14. Iron & steel making I	16. Pyrometallurgical extraction of nonferrous metals I	18. Hydrometallurgical extraction of precious metals I	20. Pre-treatment of metal-bearing waste
13. Hydrometallurgy	15. Iron & steel making II	17. Pyrometallurgical extraction of nonferrous metals II	19. Hydrometallurgical extraction of precious metals II	21. Metal recycling
	Lab exercise Smelting experiment and mass balancing	Lab exercise Simulation of a copper converter	Lab exercise Leaching experiment	
	Lab exercise Smelting experiment and mass balancing	Lab exercise Simulation of a copper converter	Lab exercise Leaching experiment	

In addition to theoretical lectures and classroom examples, laboratory exercises are part of the syllabus. This comprises experimental test work on process technology used in ore dressing at the company's laboratories or at the university, depending on the course venue.

3.2.7 Examination and credits

Attendance at the lectures and the practical exercises are compulsory.

The course is valued with 5 ECTS credits, split into 2 credits for the assignments, 1 credit for the practical exercises and 2 credits for the written exam. The exam is graded and determines the grand grade of the course.

3.2.8 Course literature

- Wills, B.; Napier-Munn, T.J. (2006). Mineral Processing Technology: An Introduction to the Practical Aspects of Ore Treatment and Mineral Recovery, 7th ed., Butterworth-Heinemann, ISBN 978-0-7506-4450-1
- Schlesinger, Mark E. (2011). Extractive Metallurgy of Copper, 5th ed., Elsevier Ltd., ISBN 978-0-08-096789-9.
- Biswas, A. K. (1999). Principles of Blast Furnace Iron Making, SBA Publications, Calcutta, 1999
- Worrell, E.; Reuter, M. (2014). Handbook of Recycling: State-of-the-art for practitioners, Analysts and Scientists, 1st ed., Elsevier, ISBN 978-0-12-396459-5.
- Handouts of the presentation material will be provided by the course authors.

3.2.9 Course evaluation

Course evaluation will be conducted after the course has ended, using a web-based questionnaire. The results of this questionnaire will constitute part of the basis for analysing the outcomes of the pilot testing phase in the final report of the project (also see chapter 4).

3.3 FULL STUDY PROGRAMME: "MINERAL RESOURCE MANAGEMENT IN THE ARCTIC"

3.3.1 Background

The Arctic region, and Greenland in particular, has previously been identified as an area with significant geological potential, but thus far have experienced relatively little mining activity (Sand, Rosenkranz 2014a). Greenland as an autonomous country within Denmark has a small population. Therefore, the educational system does not extend far beyond vocational-level programmes. For higher level education, the country has close ties to Denmark, which does not have any strong educational programmes focused on mineral raw material extraction and processing. Within COBALT, this region was therefore identified as an interesting candidate for developing a full university-level educational programme devoted to mineral raw materials.

Mining on Greenland is challenging due to the climate conditions as well as infrastructural and economic circumstances related to the relatively high cost of logistics and energy. Additionally the characteristics include a sensitive environment and the need for special societal and cultural considerations. For instance, Greenland does not allow private land ownership which generally puts requirements on locally negotiating and agreeing upon the terms of land usage. Access to skilled workers in sufficient numbers is also a limitation. Due to its small population, it is unlikely that Greenland in a situation with a rapidly expanding extractive sector could meet the demand for mining professionals solely by domestic supply.

Since the Self-Government Act of 2008, Greenland enjoys a high level of autonomy and thus exercises significant self-rule over domestic issues, while Denmark retains control of foreign affairs, defence and monetary policy. With the adaptation of a new structure of the Self-Government Act in 2009, the influence of Greenlandic authorities is expected to gradually increase in issues related to e.g. the judicial system, border control, mineral resource activities and the financial system. The ambition is to eventually move towards full independence. It is also expected that the annual subsidy currently obtained from Denmark will gradually decrease, as Greenland gains more independence and increases its incomes from mineral extraction activities (Statsministeriet 2010).

3.3.2 Mentoring institution

The Technical University of Denmark, DTU, is through the Arctic Technology Centre (Artek) the institution in Denmark responsible for educating university-level engineers with strong emphasis on the Arctic. Artek is run in collaboration between KTI (Tech College Greenland) in Sisimiut and DTU. The activities are mainly focused on construction, infrastructure, logistics, energy and environmental engineering. With regard to mineral raw materials, the study offer also includes a number of courses in geology, rock physics and rock mechanics, and mining related environmental engineering (www.artek.byg.dtu.dk). Artek has shown interest in developing their competence in mining-related topics and expanding their educational offer by developing a dedicated study programme on Master's level with focus on mineral resource management in the Arctic (Sand, Rosenkranz 2014b).

3.3.3 Identification of required graduate skill set

In discussion with representatives of DTU (Sand, Rosenkranz 2014b), a desired skill set of prospective graduates of an educational programme in Mineral Resource Management in the Arctic was defined. The aim is to take into consideration both regional needs and limitations. This includes local labour market conditions, expected need for technical, environmental, and judicial skills to work in the Arctic and on Greenland, as well as an understanding of small community, social responsibility and sustainability issues. It is expected that graduates of the programme will need to be generalists rather than possessing detailed technical expertise. Their skill set should include an understanding of permitting processes, over and underground legal framework, raw material market understanding, a broad technical overview of mining and processing operations, as well as risks and remediation activities. Technical competence will most likely need to be acquired externally for the implementation of mining projects.

The Greenlandic government is lacking the resources for in-depth evaluation of mining projects and this can also be a constraint in terms of permitting processes (Hansen 2013).It has therefore been suggested that a graduate from the mineral raw material programme at Artek should be able to perform the following tasks: to act as an intermediary in the negotiation of prospecting, environmental and mining permits between the Greenlandic authorities and mining companies; be able to evaluate information provided by mining companies; mediate information between companies and authorities, and possibly also civil society. This person should thus have an understanding of the social and cultural situation prevalent in the region. The desired skill set is summarised in Table 4.

Table 4. Graduate skill set summary

- Management skills enabling person to act as mining company- government intermediary
- Raw material market understanding
- Local understanding of Arctic issues
- Competence in legal framework of Greenland and Arctic (over and underground)
- Able to act as consultant to mining companies
- Understanding of small community, social responsibility and sustainability issues
- Understanding the technical processes of mining and mineral processing on a generalist level

3.3.4 Planning considerations

The development of a Master's programme on Mineral Resource Management takes into consideration the existing course offer at Artek and DTU as well as the unique regional conditions in the Arctic. The programme should offer courses that to a reasonable extent cover the requirements as specified in the desired skill set. Short term, within 5-10 years, it is unlikely that a devoted programme can be implemented at DTU and Artek without collaboration with other educational institutions or extensive involvement of external consultants or training providers. The programme therefore partly needs to be a compromise with existing programmes and course offers at DTU and partly include relevant new topics that can feasibly be developed at DTU or offered through collaboration with other partners.

In the suggested study programme below, the following considerations have thus been implemented as part of the plan:

- Any suggested study scheme is to be planned in accordance with regulations of the Bologna system and set up as a 2-year 120 ECTS Masters programme (ECTS Users' Guide 2009). The courses and programme contents need to be designed so that BSc graduates of at least some existing DTU programmes will have the appropriate background skills to enter into the programme.
- To make a start-up of the programme more feasible, existing DTU study programmes and courses need to be taken into account. I.e. there should at least be some synergies with existing courses at DTU/Artek, such as *Arctic infrastructure* or *Arctic mineral resources, environmental impacts and prevention*. This includes considerations aimed at avoiding teaching staff restrictions, resource utilisation

overlaps with other courses or the need to teach the same or similar courses multiple times the same year.

- Both theoretical and practical field work in the Arctic is seen as an essential part of the programme. Due to climatic and infrastructural reasons, this part of the programme will need to be placed during the spring term, and thus the 2^{nd} semester will be the only feasible option.
- Some elective courses need to be included, but in that case it needs to be ensured that no problems are caused in terms of eligibility for future courses within the programme and that each permutation is deemed feasible from the student's perspective.
- There needs to be progression in the order courses are to be taken, i.e. there should be a gradual increase in complexity and the same concepts should not be repeated in succeeding courses unless the level of complexity can be increased appropriately.

3.3.5 Student background

Course prerequisites within the programme as well as requirement for progression will restrict the admission of students based on their educational background. Suitable students entering the programme could include Bachelor degree graduates in civil or process engineering, chemical or environmental engineering or related engineering fields. For DTU students, this would primarily include BSc or BEng graduates from the programmes in Arctic Technology, Building and Civil Engineering and Environmental Engineering.

Primarily, background requirements for courses included in the programme limit eligibility. The students thus need to at least have a basic understanding of rock mechanics, geology, chemical or environmental technology, and process engineering (e.g. mineral processing or mechanical process technology). The topics above should mostly have been covered during the above-mentioned Bachelor programmes at DTU. There is, however, a possibility to develop various schemes that support and advise Bachelor students and graduates interested in entering into the programme. In addition to counselling and early stage information on required courses, it would also be recommendable to find additional arrangements that can expand the recruitment base. One option could envisage an extracurricular or summer-school type course ("preparatory classes") for students not fulfilling all entry requirements. It would also be recommendable to design a course early in the programme that allows students of differing backgrounds to catch up on specific topics not absorbed during their Bachelor studies.

3.3.6 Programme structure

Planning and structuring of the course schedule for the new Master's programme takes into account the desired graduate skill set as defined in section 3.3.3, the considerations discussed in section 3.3.4 and 3.3.5 as well as necessary prerequisites in student background knowledge. The tables below present a draft programme syllabus.

1st Semester (Autumn), Denmark

First term		Second term
Engineering and environmental sustainability, 5 ECTS	Engineering in mountains – Soil, Rock and Nature, 5 ECTS	Business Administration 5 ECTS
Mining Project Feasibility Study, 7.5 ECTS (possibly arranged partly as distance education)		Mining and Environmental Laws, 7.5 ECTS (possibly arranged partly as distance education)

2nd Semester (Spring), Greenland

Arctic Mineral Resources, Environmental impacts and Prevention, 7.5 ECTS or The Arctic Nature and Societies, 7.5 ECTS	The Arctic Infrastructure, 7.5 ECTS	Industrial Plants and Infrastructure Constructions in the Arctic, 15 ECTS or Arctic Technology, 15 ECTS (Feb-Dec)

3rd Semester (Autumn), Denmark or Other University

Mineral Processing, 7.5 ECTS	Mine Development Project Course, 7.5 ECTS
Open Pit and Underground Mining, 7.5 ECTS or Fundamentals of Rock Mechanics, 7.5 ECTS	Mining Economy and Risk Evaluation, 7.5 ECTS or Natural Resource Economics, 7.5 ECTS

4th Semester (Spring), Denmark, Greenland or Other University

Master Thesis Project, 30 ECTS

3.3.7 Course syllabi

A number of existing courses at DTU have been found suitable for inclusion into the new Mineral Resource Management programme. As regards contents not covered by existing courses, suggestions are made on how new courses could be developed. Syllabi of existing courses thus need to be thoroughly scrutinised in order to identify admission constraints, content overlaps, progression risks, as well as to ensure that the appropriate graduate skill set can be accomplished. In the section below, syllabi of existing courses are listed. Course status and need for development is discussed. Syllabi recommendations for planned courses are also given.

3.3.7.1 ENGINEERING AND ENVIRONMENTAL SUSTAINABILITY, 5 ECTS

Background requirements

Relevant bachelor in chemical or environmental technology

Learning outcomes

- Give examples on how specific chemical engineering processes are related to environmental sustainability
- Systematically analyse resource requirements of specific engineering processes
- Systematically analyse the environmental impacts of specific engineering processes
- Explain requirements of environmental sustainability for specific chemical engineering techniques to other stakeholders
- Illustrate how companies include Corporate Social Responsibility into business models
- Elucidate how selected companies implement environmental sustainability in chemical processing
- Develop strategic visions on how to consider the vulnerability of natural ecosystems in improved chemical engineering practices

Contents

The course includes topics related to:

- Interaction between chemical processing and the environment, natural resource requirements, availability, and impact on natural systems.
- The role of natural resources for strategic decision processes.
- Chemical processing and environmental risks.
- Examples illustrating the way in which chemical industries have impacted natural systems and which measures have successfully reduced environmental risks from chemical engineering.

- Case studies focused on learning from selected companies how environmental sustainability is currently being discussed and considered in their strategic decisions.
- Collection of data on future availability of specific resources and projections of future environmental conditions that will enable students to discuss how chemical engineering can be guided, controlled, and motivated to establish and foster sustainable development.

Course status and comment

This course is part of the DTU/Artek study offer on Master programme level. Resource requirements, environmental impact, stakeholder communication, and corporate social responsibility are aspects highly suitable for the new Mineral Resource Management programme (see Table 4). However, more emphasis likely needs to be put on mineral extraction and processing operations rather than chemical engineering processes and renewable raw materials. Project work related to company level implementation of issues discussed at the course should preferably involve mining companies or mineral related consultancy firms as case studies. In case the course cannot be designed as discussed above, it should be replaced by a dedicated basic course for the programme.

3.3.7.2 MINING PROJECT FEASIBILITY STUDY, 7.5 ECTS

Background

Basic understanding of mining projects

Learning outcomes

- Ability to understand the content of a mining project feasibility study
- Conduct simple calculations of economic conditions and profitability of a mining project
- Describe and explain differences in feasibility studies at different project stages (e.g. Bullock 2011)
- Ability to understand and evaluate the quality of feasibility studies
- Ability to prepare economical calculations for a mining project feasibility study and estimate free cash flow

Contents

- Role of different feasibility studies
- Guidelines and criteria for resource and reserve classification
- Sources of technical information for feasibility study industry-level information
- Quality requirements of technical and economic information
- Preproduction planning and optimisation of the rate of mining in relation to the size of the resource

- Mining methods, and importance of dilution, waste rock ratio, recovery, and net smelter return
- Estimation of operating and capital costs

Course status and comments

A similar course existed as part of the Nordic Mining School Master level study offer and its content is highly suitable for the programme. Several concepts which are needed in subsequent courses are introduced, such as introduction to mining methods, feasibility studies and reporting of resources, permitting processes, economics, etc. Due to the heavy involvement of industry professionals, most of the lectures and computer exercises will, however, likely need to be arranged as distance learning, e.g. webinars. The course length today is 4 ECTS, but should be further extended to 7.5 ECTS to fit into this programme. This could be done for instance by developing more elaborate exercises and project work, as well as a more extensive theoretical coverage of the various steps leading up to a feasibility study.

3.3.7.3 MINING AND ENVIRONMENTAL LAWS, 7.5 ECTS

Background

Background knowledge from the courses Engineering and Environmental Sustainability and Mining Project Feasibility Study

Contents

- Legal concepts and fundamental principles of mining and environmental laws in the Nordic countries and in the Arctic, including special societal considerations and indigenous peoples rights
- Legal framework related to permitting processes, exploration, and resource evaluation
- Land management regulations, public and private ownership of minerals, royalties
- Legal framework of access to information, privacy, and data protection
- Social and environmental impact assessment and mitigation
- Workforce health and safety regulations
- Appeals processes
- Legal contracts and their negotiation, including employment contracts and purchase agreements
- Mine reclamation and restoration laws and certification systems

Course status and comments

This course currently does not exist, but is highly important for the programme and for achieving the appropriate graduate skill set. The course contents listed above constitute a list of desirable topics to be covered. It is likely that there will be a need to at least partly involve competences from a university law department and/ or external consultancy firms.

3.3.7.4 ENGINEERING IN MOUNTAINS – SOIL, ROCK AND NATURE, 5 ECTS

Background

One or several geotechnical or geological subjects

Learning outcomes

- Demonstrate knowledge about and show understanding of geological and geotechnical conditions in mountain areas
- Have knowledge about weathering processes and the influence on formation of foreign soil types
- Use geological maps in an engineering geological/ technical context
- Have knowledge about the engineering geological field methods that are used for mapping the extension of geological raw materials and for laboratory methods to test soil and rock materials
- Demonstrate understanding for the correlation between resource utilisation/ building and construction work and environment problems
- Have knowledge about methods for tunnelling and mining
- Be able to account for the factors that effect on the utilisation of geothermic energy
- Be able to evaluate the hydro power potential of an area
- Analyse, evaluate and use data that are necessary to carry out chosen engineering projects in foreign countries

Contents

- Soil and rocks in mountain areas (igneous rocks, metamorphic rocks), formation classification and physical/chemical quality
- Geological maps, foreign soil description, weathering and diagenesis, technical engineering investigation methods, geological material and environmental problems by quarrying, caverns, tunnels, hydropower, reservoirs and dams. Problems with landslides, earthquakes. Geothermic energy, rock classification, building material claims.

Course status and comments

The course exists within the existing Master´s study offer at DTU. The contents are in part very suitable for the Mineral Resource Management programme, but the focus is slightly skewed towards geotechnical engineering from a construction engineering perspective. Topics related to dam construction, tunnelling, mining and quarrying are however suitable for the programme, as is energy issues and the impact of large scale construction projects on the environment.

3.3.7.5 BUSINESS ADMINISTRATION, 5 ECTS

Background

One or several courses related to mineral resources and mining projects

Contents

- Project planning, economics and management
- Corporate governance for resource companies; good corporate governance, duties of directors, capital raising, overview of commodity markets
- Leadership, strategy, decision-making
- Organisational conflict in teams and groups, and its mitigation
- Communication skills; written reports and oral presentation, stakeholder communication, interacting with media
- Control processes, quality and knowledge management
- Nordic and global business culture and practices
- Social responsibility and ethics

Course status and comments

The course does not exist as part of the DTU/ Artek study offer, but could be developed in collaboration with the DTU Management department, local Business Schools, or by involving external lecturers. Competence at DTU or at nearby educational institutions on the topics described above should be available. Based on the graduate profile and skill set, a course focussed on development of the students' communication skills, understanding of project and organisational management, as well as an overview of business practices and culture is deemed highly desirable.

3.3.7.6 ARCTIC MINERAL RESOURCES – ENVIRONM. IMPACT & PREVENTION, 5 ECTS

Background

General chemistry, environmental processes or other chemical background knowledge

Learning outcomes

- Accomplish a small environmental impact assessment (EIA) of a land-based mine
- Accomplish a small EIA of an offshore production
- Identify and describe sources of emissions from natural resource winning activities
- Suggest and describe relevant technologies and procedures to prevent environmental effects
- Describe the phases in the course of a natural resource winning project
- Relate effects of emissions to the vulnerability of the surrounding environment
- Describe chemical and biological processes relevant to the fate of emissions
- Critically evaluate an EIA made by others

Contents

The course includes:

- Arctic mineral resources, EIAs, offshore production
- Oil spill response and prevention
- Seismic investigations, drilling technologies, land-based mines
- Solid and liquid wastes of mining and offshore production,
- Water treatment, tailings handing, sulfidic, cyanide and radioactive wastes, dust emissions,
- Closing and recultivation

Course status and comments

The course is part of DTU/ Artek's Greenland semester. Due to the focus on mineral resources in the Arctic, the course is highly suitable for the programme. There are some elements that are related to off- or onshore oil extraction. One needs to consider if these parts should be included or toned down if lecturing this course as part of a Mineral Resource–related programme. The actual 5 ECTS credits could be extended to 7.5 ECTS, for instance by including more elaborate project work. The background knowledge needed to participate in the course should likely have been covered already in the students' Bachelor studies.

3.3.7.7 THE ARCTIC NATURE AND SOCIETIES, 7.5 ECTS

Background requirements

This course is at MSc programme level, but no background requirements have been listed. It mainly constitutes an introduction to the Arctic, and is as such an introductory course within the Arctic semester.

Learning outcomes

- Explain and carry out safe operations in the Arctic
- Explain and quantify the Arctic climate
- Classify typical Arctic physical environments
- Characterise snow and ice conditions
- Use advanced surveying techniques
- Use and design digital maps and databases (GIS)
- Define typical societal and business structures in the Arctic
- Discuss working conditions for engineering in the Arctic

Contents

The course includes:

- The Arctic climate and nature, the cryosphere
- Surveying, GIS and geodesy

- Social and business perspectives relevant for engineers
- Arctic resources
- Snow and ice conditions
- Historical background, business and educational conditions in the Arctic
- Natural and living resources of the Arctic
- Working conditions as an engineer in the Arctic

The course also includes mandatory safety training and SAR theory, practical exercises and excursions.

Course status and comments

The course is part of DTU/ Artek's newly planned Greenland semester. It provides a good toolbox for understanding Arctic conditions and working as an engineer in the Arctic and, thus, is highly suitable for the full study programme on "Mineral resource Management in the Arctic".

3.3.7.8 THE ARCTIC INFRASTRUCTURE, 7.5 ECTS

Background requirements

The Arctic Nature and Societies course, or equivalent, is required as background knowledge.

Learning outcomes

- Demonstrate and discuss key aspects of settlement and infrastructure planning
- Demonstrate knowledge about different solutions for heating and energy
- Design solutions for water generation and distribution
- Define the need for and sketch solutions for handling and treating waste water and solid waste
- Describe solutions for the logistics for a construction or exploration process
- Discuss social impact assessment (SIA) in relation to large installation
- Demonstrate the consequences of large scale investments
- Discuss a strategy for sustainable development for a district or settlement with scenarios, analysis, creative processes and discussion paper
- Communicate and interact professionally with other professionals, the political level and citizens

Contents

The course includes:

- Sustainable local and regional development
- Strategic and physical planning
- Settlement and infrastructure
- Logistics in the Arctic
- Strategic regional development with focus on settlements

- Transportation and business,
- Sustainability of large industrial plants including SIA
- Infrastructure design including roads, water, heating, electricity, waste and waste water.

Course status and comments

The course is part of DTU/ Artek's newly planned Greenland semester. It is focused on engineering skills in the Arctic on a generalist level. This ensures suitability of the course for the programme, as it teaches engineering students to find adapted solutions to Arctic conditions.

3.3.7.9 INDUSTRIAL PLANTS AND INFRASTRUCTURE CONSTR. IN THE ARCTIC, 15 ECTS

Background requirements

The Arctic Nature and Societies, or other study entity that includes safety course

Learning outcomes

- Perform geotechnical investigations and geophysical measurements
- Analyse and describe permafrost
- Analyse rocks for blasting and tunnelling
- Design foundations, roads and airports in areas with permafrost
- Design port facilities in icy waters
- Design tunnels and dams for hydro-electric power plants
- Design infrastructure systems for mining in remote areas
- Manage logistics, safety, work and social environment in remote production facilities

Contents

The course includes:

- Geotechnics and geophysics, permafrost
- Industrial installations, infrastructure constructions
- Site investigations, geophysics measurement methods, core drilling
- Rock mechanics, mechanical properties of snow and ice
- Thermal modelling
- Construction of roads and landing strips, tunnelling, harbour construction, hydroelectric power plant construction, infrastructure for industrial plants
- Arctic logistics

Course status and comments

This course is part of DTU/ Artek's newly planned Greenland semester. Understanding of Arctic infrastructure as well as construction engineering related to logistics, tunnelling and dams is important for the programme.

3.3.7.10 ARCTIC TECHNOLOGY, 15 ECTS

Background requirements

The background requirement includes one or more courses related to the topic the student wants to study in the arctic context

Learning outcomes

- Be able to investigate and document the state-of-the-art of a specific topic in the arctic context (e.g. raw material related)
- Find and use relevant technical information and scientific literature
- Demonstrate insight into other Arctic issues beyond one's own specialist area
- Plan and accomplish a field work in the Arctic
- Suggest, assess and choose methods in relation to the objectives of the project
- Give and receive peer-feedback on written work and oral presentations
- Argue based on cultural and social insight
- Evaluate results critically
- Analyse and impart results in a meaningful way
- Summarise own and others results
- Write a scientific-level article including abstract, quotations and references

Contents

The course is relatively freely set up around a project work where the students can select their own topic of interest (from a project catalogue). Within the Mineral Resource Management programme the project needs to be related to the Arctic context as well as to mineral raw materials. Thus, the project can involve analysis and evaluation of some aspect of an existing mining project, or case studies related to existing or closed down mines. It could also involve civil society or policy-aspects within the raw material context.

The work is carried out as follows:

1) Spring semester - the student prepares and plans the fieldwork, completes assignments and attends lectures that help them prepare for the fieldwork. Lectures can include e.g. Arctic nature and culture, buildings and infrastructure, energy supply, environmental technology.

2) Summer period– Conducting fieldwork.

3) Autumn period – Sample analysis and reporting the project. The focus of the project is on technical challenges in Greenland, but also taking into account environmental, social and cultural aspects.

Course status and comments

The course is currently lectured in Lyngby/ Denmark during the spring, and followed by a summer/early autumn field work in Greenland. It is with current scheduling not suitable within the Mineral Resource Management programme, but its content is nevertheless relevant. The course is added as an elective option within the programme plan, in case it can be rescheduled in the future or adapted for the programme. It might also be possible to adopt as a special "summer school" option for interested students, in case special arrangements related to the lab- and project work and reporting during the autumn can be made.

3.3.7.11 MINERAL PROCESSING, 7.5 ECTS

Background requirements

90 ECTS chemical engineering including previous course on mineral processing/mechanical process technology

Learning outcomes

- Understanding of mineral processes from ores, industrial minerals, recycling products, mineral fuels
- Calculate technical-economic conditions for winning of mineral resources
- Describe and explain commonly occurring processes for mineral beneficiation
- Analyse reasons for selection of processes based on raw material properties
- Generalise knowledge of process conditions to suggest process selections for hypothetical raw materials

Contents

- Ore processing
- Particle technology
- Industrial minerals and fuels
- Environmental issues, e.g. handling of process water and solid waste
- Recycling
- Management and mineral economy
- Project assignments, computer laboratory classes, industry visits

Course status and comments

The course is currently not available to DTU students. It would give the students necessary background and understanding related to mineral processing operations including unit operations, a technical-economic understanding of mineral production, process flow sheets, as well as environmental considerations and waste handling. The aim of the course is not to provide a strong technical understanding, but rather to give an overview of mineral processing.

3.3.7.12 OPEN PIT AND UNDERGROUND MINING, 7.5 ECTS

Background Requirements

Introductory course in rock mechanics and/or rock engineering

Learning outcomes

- Understanding of open pit and underground mining methods
- Develop and plan mine production
- Select suitable mining equipment
- Understanding how mining methods influence economy and product quality

Contents

- Open pit mine design and mine planning
- Underground mining: open stopping, cut and fill, caving methods
- Computer-based tools for planning, design, operation and evaluation
- Selection of mining method, equipment, necessary development work and ore losses
- Environmental impacts based on mining method
- Project assignment and study visit

Course status and comments

This course is currently not available to DTU students. It would give the students necessary background and understanding related to mining operations; mine planning, mining methods, computer-based tools, influence of mining methods on economy, product quality and environmental impact. Again, the aim is not to provide a strong technical understanding, but rather to give a technical-economic overview of mining.

3.3.7.13 FUNDAMENTALS OF ROCK MECHANICS, 7.5 ECTS

Background Requirements

Knowledge in solid mechanics and geology

Learning outcomes

- Ability to judge which rock properties are important for the performance and stability of a rock construction
- Understand the importance of and being able to carry out pre-investigations
- Understand the principles of hemisphere projection and be able to carry out stability analyses using the method
- Suggest optimal shape and orientation of underground constructions and optimal excavation sequence with respect to the state of stress and structural geology
- Understand the different failure mechanisms of rock and be able to judge if failure will occur or not
- Understand the importance of deformations for different kinds of rock constructions

and how this affect the design
- Identify potential failure mechanisms in slopes and judge whether they are critical or not
- Choose a suitable method/ criterion to determine or estimate the deformation and failure behaviour of the rock

Contents

- Structural geology, geological structures in rock and their significance from a rock mechanics perspective
- Mapping of joints, rock mass classification methods, hemisphere projection
- Virgin stresses in the rock mass, stress measurement, absolute and effective stresses, stresses around underground openings, shallow and deep seated excavations, Mohr stress circles
- Constitutive laws for rock deformation, failure laws and failing criteria, experimental methods to determine deformation and strength parameters
- Design and stability of underground constructions and rock slopes, effects of groundwater and on groundwater, drainage
- The course includes lectures, home and laboratory assignments, a field assignment and a field trip.

Course status and comments

This course is added as an elective course that can be taken instead of Open Pit and Underground Mining. The course currently does not exist as part of DTU/ Artek's study offer.

3.3.7.14 MINE DEVELOPMENT PROJECT COURSE, 7.5 ECTS

Background Requirements

General BSc-level competence in engineering

Learning outcomes

- Mine development, mining methods, equipment, personnel, etc.
- Project management, time planning, data collection
- Critically evaluate work by others, related to mine development and project planning

Contents

- The course is set up as a project work, with data collection from mining companies and literature surveying
- Project assignment, review and feedback on work by others, presentation

Course status and comments

This course would give students the necessary understanding of mine project planning and related data collection. Moreover, it also gives the ability to critically evaluate mining project and mineral extraction plans from a technical and resource perspective.

3.3.7.15 MINING ECONOMY AND RISK EVALUATION, 7.5 ECTS

Background requirements

BSc-level competence in mathematics, physics, economics and natural resources, basic knowledge of geology

Learning outcomes

- Knowledge on theoretical foundations for mining and mineral economics
- Identify and evaluate risks in mining projects
- Explain most important issues in feasibility studies
- Technical and economic analysis of proposed mining projects
- National and international regulatory framework of evaluating mineralizations
- Applying basic risk assessment and management tools to different mining problems

Contents

- Mining and mineral economic theory
- Evaluation of mineralizations
- Risk analysis: basic theory, risk identification, assessment and handling
- Group work and presentation of project related to the mining industry

Course status and comments

This course strengthens the students' ability to analyse mining projects out of an economic and technical perspective, to understand the regulatory framework related to reserve evaluation and to carry out risk analyses. The course currently does not exist as part of the DTU/ Artek study offer.

3.3.7.16 NATURAL RESOURCE ECONOMICS, 7.5 ECTS

Background requirements

BSc-level competence in mathematics and basic knowledge in economics

Learning outcomes

- Be able to graphically, verbally and mathematically discuss optimal extraction of non-renewable natural resources over time
- Explain the meaning of resource stringency of non-renewable resources out of a physical and economical perspective
- Analyse and simulate in which way the optimal rate of extraction of non-renewable natural resources is affected over time by discount rates, resource availability, technology, competition, market demand and policy variables

- Explain the characteristics of the minerals and metals market
- Compare and evaluate the relevance of economic and political control instruments used for counteracting environmental problems in the raw materials sector
- Discuss aspects of the term sustainable development with focus on its use, relevance and implications in the raw materials sector
- Communicate analyses to others with comparable expertise

Contents

- Partial equilibrium models for commodity pricing
- Comparative statistics, discounting and the Hotelling model applied to optimal extraction of natural resources
- Supply and demand factors within minerals and metals markets, also related to by- and complementary products, and recycling
- Basic welfare economics and terms such as external effects and collective goods
- Control instruments such as environmental taxes, fees and regulations

Course status and comments

This course is added as an elective course and can replace Mining Economy and Risk Evaluation in the 3rd Semester. It is suitable to students who want to gain a particularly strong background in natural resource economics, and wish to learn the most common mathematical tools for calculating pricing and statistics related to raw materials. The course currently does not exist as part of the DTU/ Artek study offer.

3.3.8 Continuous programme improvement

The programme outlined above is designed to be a feasible starting point, while at the same time it recognises the need for continuous improvement of the programme either by streamlining of existing courses, development of new dedicated courses or replacing less relevant courses, or courses that are difficult to appropriately adjust to the scope of the new programme. Here, a number of such instances are discussed.

The course "Engineering and Environmental Sustainability" includes several relevant topics, e.g. corporate social responsibility and the relationship between industrial processes and environmental impact. However, the focus of this course is more directed towards chemical industry than raw material extraction or processing operations. It is recommended to replace this course by a more general programme-related one which contextualises the topic of mineral resource management in the Arctic and provides an overview on the various aspects of mineral resource management later to be covered in greater detail.

The programme currently does not include any course in geology, as many students entering into the above-mentioned programme to some extent should have acquired this knowledge during their Bachelor studies. If it is found to be relevant to increase the geology part of the programme, this could be addressed by for instance including process mineralogy.

3.3.9 Risk analysis

The development of a new educational programme always bears risks, which may be related to setup and running costs, labour market risks and student numbers. Some of these risks are addressed below.

Labour market risks may involve a lower than expected need for graduates with the given skill set. Such risks can be especially relevant in this case since mining activity in Greenland - despite its potential - is currently very limited. This programme would, however, give a broad skill set within administration and managerial work related to Greenfield mining projects in general and not necessarily limited to cold-climate regions. Graduates with an understanding of permitting processes, law, and administration related to mining projects are expected to be high in demand especially within junior mining companies. There are also opportunities for graduates of the programme to work within consultancies or authorities. The cold-climate perspective can in addition to the European Arctic also find suitability in countries with strong mining activity such as Canada, the United States and Chile.

In addition to external risks there are also a number of study programme-related risks, for instance in terms of balancing administrational and technical courses. It is clear that the students need to have a general understanding of the technical processes of mining, processing, and waste handling as well as related environmental technology, energy, and infrastructure requirements to meet the needs defined in the skill set (Table 4). These needs are covered in the suggested study plan. Related to the administrational and economy-related courses, the structure of the programme has been designed to meet all requirements set up in the skill profile definition. The programme also has a strong emphasis on presentation skills, carrying out project work in small groups, which should accommodate the learning of skills related to communicating results to various recipients.

There is a risk that some required skills have not been appropriately addressed in the skill profile, and consequently one might need to adjust the profile over time. To monitor this, continuous programme evaluation and possibly also course modification is required. It is recommended to attach a professional advisory board composed of representatives from prospective employers to act as advisors in the continuous development of the programme.

3.3.10 Discussion

Based on DTUs Bachelor programmes and existing study offer on Master's level, it was found possible to create a course structure for a Mineral Resource Management programme. However, all technical competences related to mining and processing and also to some extent within raw material management could not be found in-house at DTU. The suggested course structure will therefore at least during the initial setup of the programme require support from either external training providers, consultancies or other educational institutions. It thus needs to be stressed that the proposed structure within this report constitutes a suggested construction which marries the existing expertise of DTU/ Artek with competences needed to procure externally in order to satisfy the specified graduate skill set.

Consequently, the implementation of a Mineral Resource Management programme would preferentially be within a double, multiple or joint degree framework in collaboration with one or more universities having complementary study offers and an interest in developing a similar type of educational programme. It would also be possible that DTU after a period of running a collaborative educational programme could build up the necessary skills and contacts for autonomously running the programme. Any such decisions will be at the discretion of DTU and Artek.

4 CONCLUDING REMARKS

This report presents suggestions for mitigating skill shortages related to the mineral raw materials sector in the European Union on three different levels, and in the three defined COBALT regions. An introductory level short course, a specialist training-type block course, and a full study programme are presented with full course schedules and course lists, respectively. Course and programme designs have been planned taking into account recent pedagogical theory (Biggs, Tang 2007).

4.1 IMPLEMENTATION PHASE

The next steps within work package 3 will be dedicated to testing the developed training courses in a pilot phase in order to validate the designed concepts. This applies for the main part to the short course and the block module course where pilot testing is planned in one of the countries of the COBALT regions "Eastern Europe" and "Iberian Peninsula", respectively (Sand, Rosenkranz 2014a). An implementation of the third case, a full study programme as developed for the North Sea region, is beyond the projects' scope and, thus, only the plan can be evaluated by the mentoring institution DTU/Artek based on the blueprint curriculum. The setting up of a new study programme is a long term process which implies approval by several administrative bodies of the university. Furthermore, the start-up of new academic programmes in Denmark is subject to evaluation and approval by an external accreditation procedure (Danmarks Akkrediteringsinstitution), with a time scope far beyond this project's life span.

For the short course "Introduction to minerals and metal production" it is envisaged to offer it in cooperation with a public agency that will likely be identified at the 3rd Regional Dialogue in Romania. The block module course "Sustainable metal production and recycling" has already been discussed with staff from different Spanish and Portuguese universities during the 1st Regional Dialogue in Madrid and positive feedback was received. These contacts will be intensified during autumn 2014.

Decisions on the selection of methods for teaching and instruction will be made together with the mentoring institutions, particularly with regard to the extent of particular teaching formats, e.g. internet-based distance education. In any case e-learning platforms will be used for managing the distribution of lecture manuscripts and the submission of assignments, as well as for communication between teachers and participants.

It needs to be stressed that the educational plans developed within this part of the project can still be subject to revision before or during the pilot testing phase, e.g. in the interest of streamlining contents for a particular target audience. This can include taking into account the background knowledge of course participants or based on prerequisites or adjustments negotiated in collaboration with mentoring institutions.

4.2 EVALUATION OF PILOT TESTING

Within the pilot testing, the interaction of the students with both the short course and the block module course will be analysed based on questionnaires. This comprises the retrieval of information related to

- The student's own efforts (preparation, attendance)
- The reception of the course (objectives, content and planning)
- The support (teacher's input, course material, learning platform)
- The student's impressions (workload, level of difficulty, examination, coherence with objectives)

Results will be used not only for the course evaluation itself but also for validation of the defined course assessment tools as part of the quality assurance.

The evaluation of the full study programme plan and syllabus will be conducted in working meetings together with the mentoring institution DTU/Artek. If necessary, the developed blueprint will be revised based on the feedback from these meetings.

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