TIMREX: Deliverable D4.2 – Roadmap for skills and competences implementation

15 March 2023

KAVA Reference: 21064 - TIMREX. TIMREX - T-Shaped Master Programme for Innovative Mineral Resource Exploration
Name of the author/Responsible partner: Luís Lopes, Balazs Bodo, Vítor Correia and Tamás Miklovicz / La Palma Research Centre (LPRC)
Name of the reviewer/Responsible partner: Ferenc Mádai / University of Miskolc
Version No: v4

Contents

List of Figures

List of tables

1. Introduction

Deliverable 4.2 presents action and timewise-oriented roadmaps to deliver innovation and entrepreneurship-related skills and competencies as part of the TIMREX MSc programme as well as to continuously monitor raw materials trends and address challenges through adaptations to the curricula. The roadmap for implementation takes into account actions and activities at curricular or extracurricular level that can be applied to different teaching/learning methods, complementing the curricula, connecting the MSc with the EIT OLOs and, overall, strengthening the TIMREX programme with the involvement of non-academic partners, both during and after the current project framework.

This document builds on the content of D4.1 - Strategic implementation of innovation and entrepreneurship, where the main concepts of innovation and entrepreneurship, the connection with EIT OLOs and preliminary skills and competencies, and actions are listed. To reach the roadmaps presented in this deliverable, the following steps were done, each represented by the follow-up chapters of this document (and represented in Figure 1):

1. Review and analysis of national, European and International documents and reports that study, analyse and report skills and competencies gaps and needs, in the world in general, but, most importantly, in the raw materials value chain in particular, with identification of most important skills and competencies for a geologist (like the ones coming out of the TIMREX programme). Focus was given to skills and competencies that correlate to innovation and entrepreneurship or that contribute to these two aspects.
2. Development of a matrix with the most important/relevant skills and competencies and how they are currently matched by the planned TIMREX programme curricular and extra-curricular activities (for academic years 2022-2023), selected from the reviewed documents and the consortium expertise.
3. Based on this matrix, identification of gaps within the preliminary TIMREX curricula (mapping what skills are not provided by the teaching methodology or the ones that are provided but scarcely).
4. Planning, development and designing of actions – both curricular and extracurricular – that can be used and included in the TIMREX programme to solve the skills and competencies gaps, and strengthen the programme (some of them with the involvement of non-academic partners).
5. Deliverance of roadmaps with actions and timelines for the strategic implementation of and delivery of improved innovation and entrepreneurship-related skills and competencies that will be up-to-date, monitored and improved from here on and will be applicable in the

TIMREX MSc programme in the years to come. The roadmap is to be used to help the definition and implementation of Task 4.3 - TIMREX Innovation modules development and Task 4.4 - TIMREX Entrepreneurship modules development as well as supporting other aspects of the MSc programme.

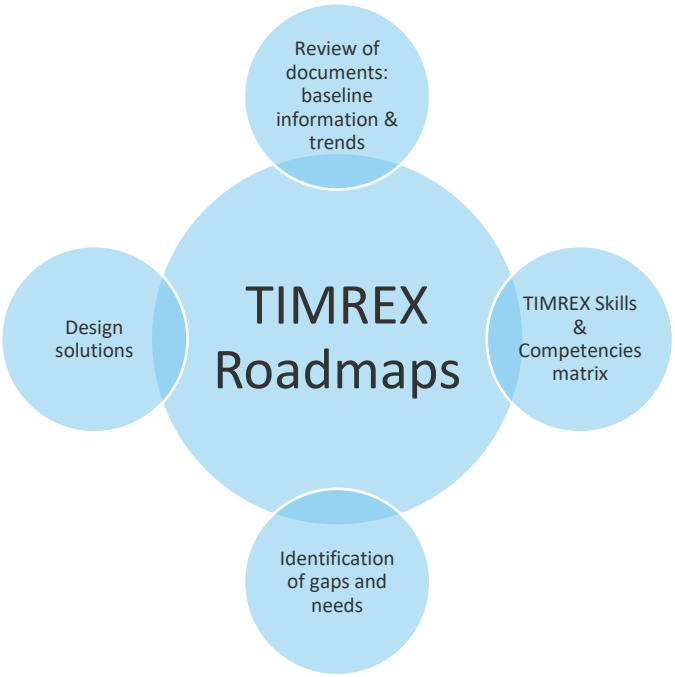

Figure 1: The building blocks that contribute to the development of the TIMREX roadmap.

2. Objectives

The main objectives of this report are to:

- Identify current and future innovation and entrepreneurship-related skills and competencies that shall be required from the future raw materials value chain workforce (and in the particular case of TIMREX, geoscientists) taking into account trends, employers' needs and other aspects.
- Identify the gaps and needs in the TIMREX education implementation plan and show how they can be matched with improved Innovation and Entrepreneurship modules provided by TIMREX in curricular and extracurricular activities.
- Suggest a list of skills and competencies centred in innovation and entrepreneurial needs to be included in the modules to deliver to students with a different set of actions.
- Provide solutions for skills and competencies deliverance for the implementation of tasks 4.3 and 4.4.
- Align the skills and competencies to be provided by TIMREX actions with the application for the EIT Label needs (contribution to OLOs, innovation, intra and entrepreneurial teaching, quality education, mobility, etc.).
- Suggest changes for improvements, adapting courses/modules and work to deliver a specific set of skills and competencies to TIMREX students.

3. Review of strategic documents reflecting on skills and competencies

Desk research and screening of relevant strategic documents, at various levels, dealing with current and future skills and competencies gaps and needs for the raw materials sector, in particular, was the first necessary step to set the stage for the preparation and presentation of the roadmaps. These different sources of information were used for orientation (what are others doing now, what is envisaged for the future), framing (what issues/topics are they focusing on) and to stimulate thinking and planning. The projects, initiatives and documents (reports, scientific papers, etc.) that were reviewed and that are seen as relevant sources of information are shortly summarised in this chapter.

The selection of the projects, reports and scientific documents for review took into account different considerations. Projects were selected on the basis of partners' previous knowledge; Reports and Scientific documents were selected based on partners' knowledge and online search. The building blocks that were extracted from the reviewing of these documents, and that were used in the work of Task 4.2 and this Deliverable, includes trends, skills, competencies and actions on many levels.

(H2020 Project) INTERMIN – reviewed deliverables 1.1 – Skills Catalogue for the Raw Materials Sector, 1.2 – Database Process Manual, 1.3 – Database and Web Interface, 2.1 - Report on Skill Gaps, 2.2 - Integrated Competency Model For Employment Across The Raw Materials Sector, 2.3 – Roadmap on Skills Provision for the Raw Materials Sector, 3.1 – International Qualification Framework for the Raw Materials Sector, 3.4 – Action Plan to Close Skill Gaps and Enhance Existing Education and Training Programmes

The INTERMIN project created a self-sustainable long-term lasting international network of training centres for professionals, with a Portal that lists training and education programmes around the world. Part of the project work focused on studying skills and competencies gaps in the education and training of raw materials topics and providing solutions to solve those gaps, including new frameworks. The reports that were reviewed focus on skills and competencies, their current gaps and future needs, models and frameworks for education and training programmes.

(EIT RawMaterials Project) MOBI-US – Deliverable 1.5 – Chapter in the structured mobility guideline about the latest results on European qualification framework, skill and competence catalogue for the raw materials sector

The EIT RawMaterials Education-funded project, MOBI-US – structured mobilities for ESEE raw materials master programmes, presented trends affecting the raw materials sector and analysed skills and competencies gaps in the raw materials education of the partner universities and the raw materials value chain as a whole. The document makes several recommendations for implementing in the curricula planning integrated competency models, qualification frameworks and skills gaps monitoring.

(FP7 Project) COBALT – Deliverable 3.3 - Final Report On Skill Shortages And Means Of Addressing Them

The COBALT project developed a debate among stakeholders on sustainable raw materials use. In the reviewed report, the consortium made a stock of educational offers in Europe and how they try to solve skills and competencies bottlenecks. Development of full study programmes, short courses and block courses were presented as solutions to solve the bottlenecks.

(Scientific paper, Hartlieb et al., 2020) A comprehensive skills catalogue for the raw materials sector and the structure of raw materials education worldwide

This scientific paper (written by INTERMIN project involved persons) refers that raw materials education mainly focusses on “classical” raw materials related topics (geology, mining and mineral processing), whereas there are deficiencies in emerging and non-technical skills like communication and management (which largely correspond to a set of social and soft skills). The authors also present a knowledge base for future analysis of raw materials education, identifying currently taught skills and the structure of higher education. A definition of skills, knowledge and teaching areas is presented, leading to a comprehensive “skills catalogue”.

(Scientific paper; Holz-Clause et al., 2015) Current and future trends in higher education learning: Implications for curriculum design and delivery

Holz-Clause et al. ’s paper is about the transition of Higher Education from a predominantly teacher-centred mode to a non-traditional learner-oriented one and they identify that this change is mainly due to the raising importance of Information and Communication Technologies (ICTs) in curriculum design and delivery (as seen for example with the solutions of online learning). The authors discuss the current and future trends in higher education for curriculum design and delivery using online learning as a central tool for teaching. They list Massive Open Online Courses (MOOCs)

as an online teaching-learning future trend that can help provide educational access to millions of students geographically situated all over the world.

(Scientific Paper; Yaneva et al., 2022) Rethinking Education in the Raw Materials Sector through Tailor-Made Teaching Methodologies

This article presents a methodology applied to the design of a tailor-made program for teaching staff that addresses the needs of high-level educational institutions in the Eastern and SouthEastern European (ESEE) region (which are the regions primarily covered by the TIMREX education partners). The program was implemented as a one-week online course for 22 “Trainees” from six ESEE universities in 2021.

(Scientific Paper; Herrera et al. (2017) & Edelbro et al. (2017)) Implementation Of CDIO Initiative In New European Education Programs In Raw Materials & European Initiative On CDIO In Raw Material Programmes

The CDIO™ INITIATIVE is an innovative educational framework to help in the development of the next generation of engineers. The two scientific papers listed here address this initiative equally. They explore the implementation of the CDIO initiative with the objective of fostering radical innovation and guided entrepreneurship. The CDIO initiative generates a significant impact on European competitiveness and employment by driving and fostering innovation and empowering students, entrepreneurs and education partners to drive towards the circular economy. The authors state that today’s technical MSc graduates in raw materials and especially primary resources (i.e. exploration, extraction, mining and mineral processing and metallurgy) meet the technical standards required by the raw materials industry across the full raw materials value chain and that best suits large companies where they often act as specialists and experts. However, they make a reference for the need of soft and entrepreneurial skills which are clearly lacking, including: intra- and entrepreneurial mindset, students able to develop their functions in new working environments, fostering the entrepreneurial and innovation skills, knowledge and attitudes needed for the entre- and intrapreneurs of tomorrow. The CDIO framework provides students with an education stressing engineering fundamentals set in the context of Conceiving — Designing — Implementing — Operating (CDIO) real-world systems and products.

(Scientific Paper; Pacher et al., 2021) Virtual E-Learning Community Hub – For Higher Education in the Raw Materials Sector

The “Virtual E-Learning Community Hub - For Higher Education in the Raw Materials Sector” builds on the fact that digitalisation is fast progressing and digital tools recurrently flood the market. Digital literacy has increasingly become one of the most important skills in the majority of the world and those who are unable to keep up with the rapid transition into the digital era face the risk of

reduced employment opportunities or social exclusion. It is therefore necessary to bridge the gap into the digital world, as well as, to serve with an adapted methodological-didactical framework to encourage auto-didactical learning at a high level, with an emphasis on the Raw Materials sector.

(Report; World Bank Group, 2019) The Changing Nature of Work

The Changing Nature of Work report paints a global picture with the skills and competencies changes and needs in general, and how the world is transforming into a digitally-based, competitive, human capital and lifelong learning based world that in itself requires workers to have new sets of skills.

(Report; European Commission, 2016) A new skills agenda for Europe - Working together to strengthen human capital, employability and competitiveness

This report presents European priorities for addressing the needs in skills and competencies for Europeans – both students and workers alike. The identified priorities are:

- Improving the quality and relevance of skills formation
    - Strengthening the foundation: basic skills
    - Building resilience: key competences and higher, more complex skills
    - Making VET a first choice
    - Getting connected: focus on digital skills
- Making skills and qualifications visible and comparable
    - Improving transparency and comparability of qualifications
    - Early profiling of migrants' skills and qualifications
- Advancing skills intelligence, documentation and informed career choices
    - Better information for better choices
    - Boosting skills intelligence and cooperation in economic sectors
    - Better understanding the performance of graduates

Furthermore, the report also mentions that the following actions are important to be implemented:

- More work-based learning and business-education partnerships
- More support for learners' mobility

- More learning at the workplace
- More opportunities to validate non-formal and informal learning
- Supporting teachers and trainers
- Modernising higher education

A common topic among these points is the necessity for students and workers of acquiring entrepreneurial and soft skills alike.

(Report; EY, 2019) The Future of Work: the Changing Skills Landscape for Miners

This report presents the future skills required of the mining industry workforce, addressing how stakeholders can stay ahead of the changing environment. It makes reference to the impacts on the value chain and lists actions that can be taken to address the skills and competencies changes.

(Report; Meller and Salinas, 2019) Revolución Tecnológica 4.0 y Capital Humano

This report focuses on the changing nature of the raw materials value chain (especially the mining aspects) and how the human capital is raising in importance for the Industry 4.0 advancements. Skills and competencies for the changing environment are listed as are the technological trends that will have impact on the raw materials sector, and thus on the skills and competencies needed by several types of workers, including geologists.

(Report; The Chronicle of Higher Education, 2019) Responding to Work-Force Needs

Responding to workforce needs is a report that intends to show stakeholders' views on how higher education institutions can (and should) create partnerships with employers to provide students with relevant skills and competencies. The soft skills gap in education is one of the major points mentioned in the report.

(Report; European Commission, 2020) European Skills Agenda for Sustainable Competitiveness, Social Fairness and Resilience

This European Commission report makes reference that "we live in a time of transition" and calls for a shift in how and what skills and competencies are offered in an effort to have better prepare people and workforce for European industries. The points of this report focus strengthen sustainable competitiveness, ensure social fairness, Build resilience as important pieces of the puzzle. Soft skills and lifelong learning are two of the main aspects that shall be included in the following measures and actions:

- WORKING TOGETHER UNDER A PACT FOR SKILLS
    - Pact for Skills
- SKILLING FOR A JOB: ALIGNING POLICIES TO DELIVER RESULTS
    - Strengthening skills intelligence
    - EU support for strategic national upskilling action
    - Proposal for a Council Recommendation on Vocational Education and Training for sustainable competitiveness, social fairness and resilience
    - Rolling out the European Universities initiative and upskilling scientists
    - Skills to support the twin transitions
    - Increasing STEM graduates and fostering entrepreneurial and transversal skills
    - Skills for Life (Lifelong learning)
- DEVELOPING TOOLS THAT EMPOWER PEOPLE TO BUILD SKILLS THROUGHOUT LIFE
    - Initiative on individual learning accounts
    - A European approach to micro-credentials
    - New Europass platform
- SETTING AMBITIOUS SKILLS OBJECTIVES
- MAKING IT HAPPEN: UNLOCKING INVESTMENT
    - Improving the enabling framework to unlock Member States' and private investments in skills

(Report; Mosher and Keane, 2021) Vision and Change in the Geosciences – The Future of Undergraduate Geoscience Education

This extensive report, supported by raw materials education institutions and professions from the USA, outlines the robust vision of over 1000 geoscientists in the academic and employer communities for the Future of Geoscience Undergraduate Education and key strategies for transformative change, where trends affecting the geoscientific learning scope are mentioned together with necessary skills and competencies for the current and future timeframes. Actions to provide said skills are also part of the report.

(Report; OECD, 2018) The Future of Education and Skills – Education 2030

This OECD Learning Framework 2030 offers a vision and some underpinning principles for the future of education systems.

(Report; Redecker et al., 2011) The Future of Learning: Preparing for Change

This report synthesizes and discusses the insights collected. It identifies key factors for change that emerge at the interface of the visions painted by different stakeholder groups and arranges them into a descriptive vision of the future of learning in 2020-2030. The report discusses future solutions to pending challenges for European Education and Training systems and outlines policy options.

(Proceedings; Bartha et al., 2022) Entrepreneurship In The Raw Materials Sector

The EIT RawMaterials LIMBRA ('Decreasing the negative outcomes of brain drain in the raw materials sector') project had as a major goal the creation of new entrepreneurial ideas in the raw materials sector, and at the same time fostering the participation and graduation of students in engineering in raw materials-related programmes to start their own businesses.

(Book; Herrmann and Kara, 2019) Enhancing Future Skills and Entrepreneurship

The book entitled Enhancing future Skills and Entrepreneurship aims at raising awareness, providing hands-on training, and sharing the latest knowledge in the areas of sustainability in various engineering fields to discuss the newer methods of teaching-learning and high-tech entrepreneurship. The papers are divided into three categories: sustainability, entrepreneurship, and engineering education which make reference to various topics including actions for the future, skills and competencies needs.

4. Trends in the Raw Materials Sector

The review of the strategic documents reported in the previous chapter allowed to gain valuable insights into the raw materials sector and general world current and future trends that are affecting and will affect the skills and competencies needed by the workforce. Changes in work and identified trends in skills and competencies include:

4.1 General working trends

Increase of nonroutine cognitive and sociobehavioral skills (from 33 to 41 percent) in advanced economies, which are among the skills most valued and needed by employers.

Skills that cannot be replaced by robots, including general cognitive skills (e.g. critical thinking) and sociobehavioral skills (e.g. managing and recognizing emotions) **are becoming more relevant to employers**. This is a result of many technologies which are changing what skills are rewarded in the job market.

There is a growing demand for workers who can make use of and bring emerging skills to technical fields of expertise. Demand is growing for transferable higher-order cognitive skills such as logic, critical thinking, complex problem-solving, and reasoning.

Adaptability is being highly regarded and looked for by employers. This is the ability to respond to unexpected circumstances and to unlearn and relearn quickly. Adaptability is a product from using both cognitive and sociobehaviour skills alike, which are (not coincidentally) in high demand.

The education system tends to resist change, and this can cause problems in the supply of necessary skills for the job market. Readjustment in the supply of skills needed by many industries is done through methods outside of compulsory education and formal jobs.

Tertiary education is seen as one of the main vehicles to build and transfer sociobehavioral and cognitive skills. Furthermore, universities are more and more using (and well) supporting teaching such as entrepreneurial courses to improve noncognitive skills.

The use of practical exercises and visual aids prove to be effective learning tools since they help memory. If coupled with motivational tools such as financial rewards, work experience, or frequent feedback, they greatly contribute to consolidate the learning process of students.

Apprenticeships or internships that link training to day-to-day experiences (including working experiences) and provide motivation are essential for students to develop and retain skills and

competencies. The industry should, therefore, be directly involved in the development of the curriculum and contribute to skills and competencies development to support learning.

Combining skills development through education with skills certificates, referral letters, and better information about job opportunities, which can be provided by education partners, will boost effectiveness of education courses, especially for women, thus contributing to extending diversity in education programs.

Personalisation, collaboration and informal learning will be at the main components of the learning process. Learning will be highly shaped by lifelong and life-wide learning with the support of ICT knowledge and tools. Personalized learning and individual mentoring will also become a reality and teachers will need to be trained themselves in order to be able to exploit resources and tools to support tailor-made learning pathways and experiences. Along with changing pedagogies, assessment strategies and curricula will need to change, and, most importantly, schools and universities, vocational and adult training providers, will need to reposition themselves in the emerging learning landscape. In particular, they will need to respond more flexibly to individual learners' needs and changing labour market requirements.

Problem-solving, reflection, creativity, critical thinking, learning to learn, risk-taking, collaboration, and entrepreneurship will become key competences for a successful life in the European society of the future.

Formal education and training should equip everyone with a broad range of skills which opens doors to personal fulfilment and development, social inclusion, active citizenship and employment.

A significant number of people in Europe have entrepreneurial aspirations, including an increasing trend towards social entrepreneurship. To make these aspirations a reality, a step change is necessary to put a focus on the development of entrepreneurial skills. Career guidance systems and practices should cover properly the entrepreneurial dimension. Raising awareness of social entrepreneurship and other social economy business models can also help increase the appeal of and interest in entrepreneurship.

4.2 Specific raw materials value chain trends

Robotics and Automation (drones, autonomous vehicles and remote-controlled operational systems) will be more used to support exploration efforts and mining operations. These innovations will reshape the skills demanded from field geologists, with greater skills in contemporary data and digital technologies being highly demanded.

Increasing demand for Data and Digital literacy skills across all phases of the mining value chain that will redesign most occupations as the human-to-machine interface evolves and becomes more prevalent.

Cloud computing, information sharing and big data continue to change the nature of work and enable integrated operating centres so more work can be performed remotely and more flexibly.

Skills requiring greater degrees of task creative intelligence, social intelligence, and perception and manipulation will be more resilient to the impacts of technology and automation: change management, collaboration, stakeholder engagement, creativity, data analysis, data and digital literacy, design thinking, stakeholder analysis, strategic planning.

Occupations are likely to be redesigned or enhanced, rather than automated. The response required by the raw materials sector will be to support the workforce through contemporary training/education offerings, and strategic workforce planning to benefit from drivers of change shaping the future of work. These drivers include:

- Shifting workforce
- Convergence of technology, robotics and AI
- Social and demographic factors
- Inclusive and Purpose led roles, attractive to millennials
- Work-life balance with flexible work arrangements
- Emphasis on building tec-capabilities and soft skills
- Higher efficiency, performance and productivity
- Better service delivery and overall employee experience
- Decline in turnover with better employee engagement
- Reduction in people and infrastructure costs
- Data centric, analytics driven decision making capability
- Work continuity during contingency and emergency

It can be expected that most occupations will use data and digital technologies much more comprehensively, especially to support decision making

Other trends observed in the minerals industry are the **continued integration of current and**

emerging technologies across the value chain. Underpinned by technologies such as robotics, autonomous transportation, and machine learning, these forces will continue to redesign operations and require personnel to have greater data and digital literacy

Skills of the future present themselves as resistant to the impact of automation, or those skills enhanced by technology resulting in greater productivity. Across a range of models forecasting future skills, common denominators indicate skills such as: entrepreneurship, art, collaborating with people, team work, communication, and design, remain resistant to the impacts of automation and digital.

Workforces need to be adequately equipped not only with the skills they need now, but also the skills demands of the future. Relevant skill based training should be introduced with foresight, scaffolded with effective change management practice advocating the case for change- the why, and introduced realistically in tandem with technological implementation so knowledge-based training can be effectively utilised on the job.

Skill development initiatives need to be balanced across both technical and soft skill competencies. The future demands more individuals who are collaborative, innovative, system-thinkers who can manage complexity and see the interconnectedness and improvements across the value chain.

There is also the need for education pathways that enable mobility between and into the sector.

References to out-dated technologies should be replaced by contemporary needs and uses of technology in the sector, supported through a revised skills gap analysis.

Education mainly focusses on "classical" raw materials related topics (geology, mining and mineral processing), whereas there are deficiencies in emerging and non-technical skills like communication and management. There is a strong need for both sides to understand the necessities and constraints of the respective other partner in this business.

An increasing number of modern mining operations are highly automated, and equipment operators have largely replaced hands-on miners. Today's mining companies are looking for graduates and technical specialists with not only mining knowledge but also the ability to use sophisticated technology and computing techniques, operating in challenging environments.

Most geoscience education and training programmes in Europe are not focused on mineral exploration or extractive industries, nor responding to the demand of recycling-related study programmes.

Currently many graduates are educated to be productive in one field of the raw materials value

chain. Barriers:

- Researchers receive a strong focus on technical excellence but very little in so called 'soft' skills e.g. social interaction, community relations and leadership
- Lack of practical training and co-operation with companies
- Lack of improvement of employability skills in technical universities. Sometimes universities are creating non employable graduates
- Few policies support collaboration between universities, research centres and industry

The next figure and table aim at complementing the trends for raw materials value chain employees with a focus on future skills. Figure 2 offers a comparison between current and future skill types' demand, while Table 1 lists important skills with growing and declining demand.

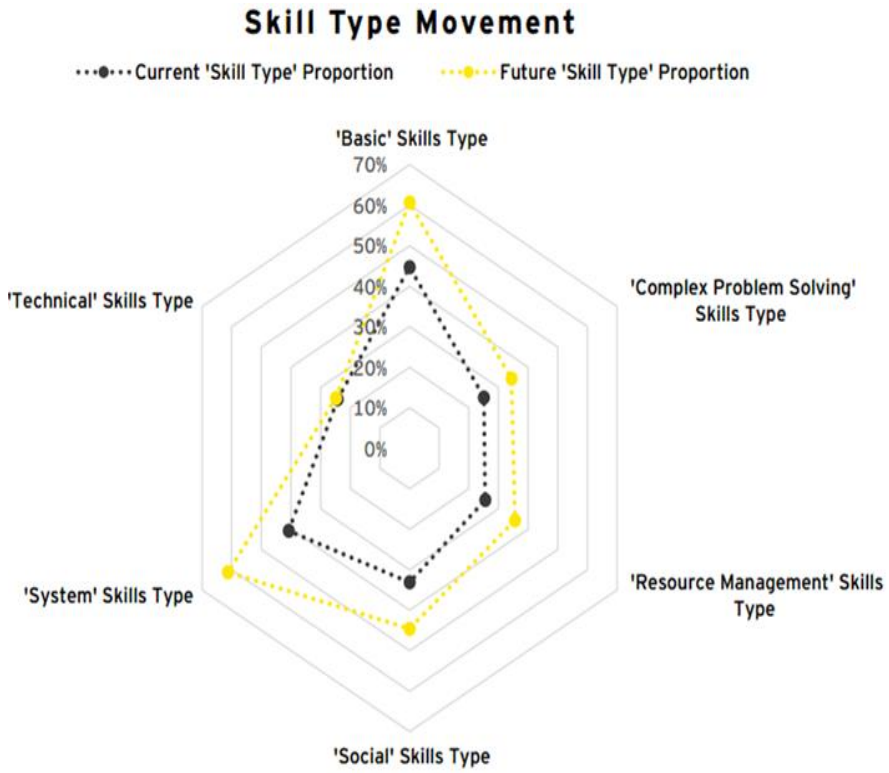

Figure 2: Skills types' changes for mining employees (EY, 2019).

Table 1: List of growing and declining skills and competencies in demand for raw materials employees. Adapted from EY (2019).

Skills with growing demand		Skills with declining demand
Systems evaluation and analysis	Management	Vehicle operations

Communication with others and teamwork	Entre and Intrapreneurship mindset	Materials extraction
Mathematics	Critical thinking	Operation and Control
Instructing	Recognising emotions	Operation monitoring
Data analysis	Use of logic	Troubleshooting
Data and Digital (ICT) Literacy	Complex problem-solving	Equipment maintenance
Writing	Reasoning	Blast hole drilling
Judgement and Decision making	Adaptability	Equipment selection
Active listening and Active learning	Risk-taking	
Social entrepreneurship	Design thinking	
Stakeholder analysis and engagement	Strategic planning	
Creativity		

5. Matrix with skills and competencies

After analysing the relevant projects, reports and documents, a matrix containing selected skills and competencies was prepared. This matrix represents the most important and relevant innovation and entrepreneurship skills and competencies, based on the reviewed documents and the experience of the consortium partners. Based on their relevance to innovation and entrepreneurship, the skills and competencies were grouped into 5 sub-categories, each containing a series of skills and competencies (listed under Annex 1):

1) Data – focus on skills that correspond to the collecting, processing and using geoscientific data (17 skills and competencies were selected)
2) Applications of technology in Mineral exploration – corresponds to skills that involve the use of technology – especially new and innovative technologies – for mineral exploration (17 skills and competencies were selected)
3) Mineral exploration knowledge and techniques – sub-area that focus on the skills and competencies inherent to performing mineral exploration activities (30 skills and competencies were selected)
4) Business Management and Entrepreneurship – includes skills and competencies that develop the entrepeurial mindset and knowledge (30 skills and competencies were selected)
5) Social tasks and performance – a diverse sub-area that counts with soft skills and competencies that are important not only for the implementation of geoscientific work, but that also are relevant for the self, including a strong linkage with innovation and entrepreneurship concepts (74 skills and competencies)

The first three sub-areas' skills and competencies are more connected to Innovation, the fourth sub-area more connected to Entrepreneurship, while the fifth sub-area addresses both Innovation and Entrepreneurship alike.

The matrix was created on a worksheet document and shared with the project partners, where, for each skill and competency listed, partners were requested to mark the ones that are planned to be covered and how they will be covered in the first TIMREX MSc planning. Samples of these matrixes are listed on Annex 2.

Table 2 shows basic information on the planned coverage of the selected skills and competencies per sub-area. This analysis made by the partners can be seen as a Business As Usual approach, since it mainly takes into consideration pre-planned teaching methodologies.

Table 2: Basic data on the coverage of relevant skills and competencies within the TIMREX MSc programme (Business As Usual scenario)

Sub-area	Skills and Competencies coverage
Data	From the 17 skills and competencies listed, 2 were not considered to be covered Education partners provide most of the skills and competencies through their courses in the curricula (15 out of 17) The possibility of internships offered by non-academic members covers 7 skills
Applications of technology in Mineral exploration	From the 17 skills and competencies listed, 6 were not considered to be covered Education partners provide most of the skills and competencies through their own courses (10 out of 17) The EFG Exploration Entrepreneurship helps to cover 1 skill, while the possibility of internships offered by other non-academic members can cover 7 skills
Mineral exploration knowledge and techniques	From the 30 skills and competencies listed, 1 was not considered to be covered Education partners provide most of the skills and competencies through their courses (25 out of 30) The possibility of internships offered by non-academic members can cover 24 skills
Business Management and Entrepreneurship	From the 30 skills and competencies listed, 1 was not considered to be covered The EFG Exploration Entrepreneurship contributes to covering 18 skills and competencies out of the 30 The possibility of internships offered by non-academic members covers only 3 skills

Furthermore, an analysis of skills and competencies delivered per mobility route of the TIMREX MSc was done. This was an important analysis to make since it shows where the mobility routes (8 possible routes) have more gaps in the relevant skills and competencies, due to having different

academic partners – and thus different skills and competencies delivered through curricular courses. The following table synthesizes the gaps in the 8 routes per sub-area.

Table 3: Basic data on the coverage of relevant skills and competencies within the TIMREX MSc programme per Route/Pathway (Business As Usual scenario)

	Data	Applications of technology in Mineral exploration	Mineral exploration knowledge and techniques	Business Management and Entrepreneurship
Route 1	Gaps in 6 skills	Gaps in 12 skills	Gaps in 8 skills	Gaps in 5 skills
Route 2	Gaps in 4 skills	Gaps in 9 skills	Gaps in 11 skills	Gaps in 10 skills
Route 3	Gaps in 4 skills	Gaps in 12 skills	Gaps in 6 skills	Gaps in 7 skills
Route 4	Gaps in 5 skills	Gaps in 5 skills	Gaps in 6 skills	Gaps in 2 skills
Route 5	Gaps in 4 skills	Gaps in 12 skills	Gaps in 7 skills	Gaps in 8 skills
Route 6	Gaps in 3 skills	Gaps in 7 skills	Gaps in 8 skills	Gaps in 3 skills
Route 7	Gaps in 3 skills	Gaps in 7 skills	Gaps in 10 skills	Gaps in 4 skills
Route 8	Gaps in 5 skills	Gaps in 6 skills	Gaps in 6 skills	Gaps in 3 skills

The Social tasks and performance-related skills and competencies coverage/gaps are not referenced in the tables since they are too many. This is, in reality, not true – it is simply an oversight by the academic partners in considering soft skills as part of the teaching methodologies and curricula, which only corroborates the need to boost the relevance for social-related skills on tertiary education.

With both analysis of skills and competencies, a few conclusions on the delivery of skills can be drawn and shed light on possible solutions to complement the curricula and solve bottlenecks and gaps (which are explored on the following chapters):

- The Data skills and competencies are well covered by the education partners with the support of the possibility of having internships at non-academic partners contributing to nearly half of those skills, especially the ones that involve collection, processing and use of geoscientific data and their application to solve industry-related problems. The data skills and competencies are also well represented in all the pathways with varying degrees, from 3 to 6 gaps in these skills.
- Skills and competencies that are connected with the uses of technology (especially innovative field and laboratory technologies) in the raw materials sector as a whole and exploration in specific are lackluster. In some instances, they are moderately covered thanks to field visits, but they would greatly benefit from internships at partners institutions to support academic learning, especially where students could learn about, have access and use new technologies. Gaps in the applications of technology in mineral exploration range from 6 to 12 skills among the different TIMREX routes.
- The Mineral exploration knowledge and techniques related skills and competencies are planned to be covered mostly with the duo academic teaching + internships at non-academic partners. These skills and competencies would greatly benefit from the integration of more internship possibilities as well as with the support of other actions such as webinars, talks and industry challenges forwarded by experts. As for coverage, gaps are identified for all the pathways varying from 6 to 11 skills.
- Business-related skills and competencies, which connect to the entrepreneurial side of learning, are well covered within TIMREX, especially thanks to the contribution of the EFG Exploration Entrepreneurship, which suggests that business and entrepreneurial-related aspects are being taken seriously by the TIMREX partnership and curricula planning. However, there is always a possibility of extending the coverage with more internships at other non-academic partners as well as with other supporting actions to the traditional teaching. In terms of gaps, these vary between 3 and 10.
- The social skills and competencies are somewhat downplayed by the partners, as seen by the high number of skills missing from the curricula planning – on the first overall analysis there were a total of 15 skills and competencies missing out of 74, which for soft skills that can be covered in multiple ways is a lot. In truth, this type of skills can be easily covered by education partners, the EFG Exploration Entrepreneurship and Internships at other partners institutions. Adding to these, there are many other ways that can complement acquiring social and soft skills.

It should be noted that the analysis of the skills and competencies is a tricky process when considering the different pathways and their inherent courses, since different pathways mean different courses. To add to this, the pathways will focus on different aspects of mineral exploration and geociences. As an example, it

was referenced that knowledge of blockchain and its applications will become an important competence. This skill is missing from all of the pathways and there is no planning to deliver this specific skill. However, it is acceptable that this skill is missing at this point from all the pathways, since this is a skill that is highly specific, still in its infancy and that, therefore, will be mostly relevant for the future. In these cases, this analysis serves more as a “signpost” for future needs and challenges that education and industry will need to address.

6. Design solutions

Following the analysis shown in the previous chapter, academic and non-academic partners alike were asked to revisit the skills and competencies list and their coverage and propose ways to solve the identified gaps (taking into account general actions already mentioned in D4.1 as well as any new ideas). This was done through a revision of the previously mentioned matrix, where partners allocated new and/or revised possible actions to solve specific bottlenecks. The identified solutions range from including small adjustments to planned courses in order to fit actions that can deliver part of the necessary skills and competencies within the TIMREX sphere to entirely new courses and activities. Resulting from the revision process the following skills and competencies suffered changes and/or adaptations towards better skills coverage:

- Data skills and competencies

Table 4: First suggested improvements and revision on the coverage of Data skills and competencies within the TIMREX MSc programme towards better skills coverage.

Skills / Competencies	New or improved measures
Is able to evaluate data, data quality, purpose of collecting data, begin with understanding of how data will answer question	Can be covered with the EFG Exploration Internship
Has experience with authentic research and collection of new information	Can be covered with the EFG Exploration Internship
Use of appropriate methods, reading and interpreting graphs	Can be covered with the EFG Exploration Internship
Knowledge on advanced/predictive data analytics, digital twinning and simulation modelling	Included into Exploration geochemistry; GIS in exploration of mineral recourse; Remote sensing – from Semester 1 UNIZG-RGNF
Knows about operation monitoring and analysis	Included into Exploration geochemistry; GIS in exploration of mineral recourse; Remote sensing – from Semester 1 UNIZG-RGNF

Understands and can implement the complex dependencies between data obtention, data processing, modelling and simulation	Included into Exploration geochemistry; GIS in exploration of mineral recourse; Remote sensing – from Semester 1 UNIZG-RGNF
Use of appropriate methods, reading and interpreting graphs	Majority of courses from UNIZG-RGNF semester 1 and 2 Most courses of WUST
Use of neural networks for data processing	GeoZS internship
Makes predictions and problem solving with limited dataMakes predictions and problem solving with limited data	Covered within the Computer Aided Geological Modelling and Geostatistics and Operations Research courses of WUST

- Applications of technology in Mineral exploration

Table 5: First suggested improvements and revision on the coverage of Applications of technology in Mineral Exploration skills and competencies within the TIMREX MSc programme towards better skills coverage.

Skills / Competencies	New or improved measures
Is technologically versatile (e.g., Google Earth, tablets, smartphones, apps)	Can be covered with the EFG Exploration Internship Covered within the Digital mine and Principles and Applications of InSAR and GIS in mining courses of WUST
General understanding of sustainability and materials & energy efficiency	Can be covered with the EFG Exploration Internship
Has industry and research awareness	Can be covered with the EFG Exploration Internship
Is able to use technology, monitor and control it	Can be covered with the EFG Exploration Internship

	Use of appropriate methods, reading and interpreting graphs – majority of courses from UNIZG-RGNF semester 1 and 2
Is able to repair mining technologies	Hands-on training in real environment or in labs
Knows about tech design, engineering, installation and maintenance	Hands-on training in real environment or in labs Covered within the Digital mine course of WUST
Is able to use technology, monitor and control it	Hands-on training in real environment or in labs Covered within the Digital mine, Principles and Applications of InSAR and GIS in mining and Engineering Geophysics courses of WUST
Is able to use sensors and computers to collect data	Covered within the Engineering Geophysics and Principles and Applications of InSAR and GIS in mining courses of WUST

- Mineral exploration knowledge and techniques

Table 6: First suggested improvements and revision on the coverage of Mineral Exploration knowledge and techniques skills and competencies within the TIMREX MSc programme towards better skills coverage.

Skills / Competencies	New or improved measures
Is aware of emerging techniques and technologies for extraction	Can be covered with the EFG Exploration Internship
Is aware of innovative exploration technique development derived from research projects such as UNEXMIN, UNEXUP, ¡VAMOS!, or	Can be covered with the EFG Exploration Internship

other projects related with geo-technologies, mineral and geological resources, or geo-exploration	
Is aware of geophysical research technics, Interpretation of the geophysical logs, downhole surveys	Can be covered with the EFG Exploration Internship
Knowledge of materials extraction techniques and technologies	Can be covered with the EFG Exploration Internship
Performs metallogenic studies, prospectively assessments and mineral exploration (metal, non-metal and energy)	Can be covered with the EFG Exploration Internship
Knows about the mineral exploration for new frontier mining e.g. deep sea and space resources	Can be covered with the EFG Exploration Internship
Knowledge on mining wastes and secondary raw materials analyses, including sampling	Can be covered with the EFG Exploration Internship
Knowledge on primary raw materials (metal, non-metal and energy) – composition and metallogenic factors	Can be covered with the EFG Exploration Internship
Knowledge of innovative exploration technologies; Portable spectroscopic techniques and their applicability and limitations (hyperspectral, XRF, LIBS, SWIR)	Partly covered as portable XRF becomes included into Analytical methods in ore deposits); Semester 2 of UNIZG-RGNF pathways
Knows about the potential of biotechnology for exploration	Lab courses or presentation of the good practices
Can do field work preparation, organization and implementation; Contemporary methods of surveying and conducting field geology	Covered within the Engineering Geophysics course of WUST

Knows how to couple geochemistry with environmental studies concerning environmental impact of mining	Covered within the Environmental management course of WUST
Knowledge of materials extraction techniques and technologies	Covered within the Operations research course of WUST
Performs metallogenic studies, prospectively assessments and mineral exploration (metal, non-metal and energy)	Covered within the Project management, Appraisal and Risk evaluation course of WUST

- Business Management and Entrepreneurship

Table 7: First suggested improvements and revision on the coverage of Business Management and Entrepreneurship skills and competencies within the TIMREX MSc programme towards better skills coverage.

Skills / Competencies	New or improved measures
Knowledge on developing and implementing risk management strategies and plans	Can be covered with the EFG Exploration Internship To add Introduction to entrepreneurship course from UNIZG-RGNF
Oversees the implementation of plans and risk management	Can be covered with the EFG Exploration Internship To add Introduction to entrepreneurship course from UNIZG-RGNF
Understands the impacts of commodity price fluctuations	Can be covered with the EFG Exploration Internship LTU covers as part of the course on Exploration and Mining Geology To add Introduction to entrepreneurship course from UNIZG-RGNF Can be managed in a form of a seminar assignment(s) in which price volatility for specific commodity can be described – historical overview, how the price

	impacted the market and how other (and which) parameters impacted on the price of commodity. Can be done also on the big scale and check the link between the mining and macroeconomic volatility
Can interrogate and interpret financial statements	WUST covers as part of the course on Exploration and Mining Geology To add Introduction to entrepreneurship course from UNIZG-RGNF
Is innovative and knows about innovation practices in mineral exploration	Can be covered with the EFG Exploration Internship Covered within the Digital Mining course of WUST Covered by LTU courses (incorporation of guest lecturers from the Swedish mining industry in e.g. Mining Geology and the show-casing, the use of examples from ongoing and recently completed industry-collaborative research programs, the use of industry standard software such as ioGAS and Leapfrog)
Knows how to manage contracts, contractors and consultants	To add Introduction to entrepreneurship course from UNIZG-RGNF
Can manage projects, organisations and teams. Shows leadership	To add Introduction to entrepreneurship course from UNIZG-RGNF
Prepares and manages budgets and assets & Allocates resources	To add Introduction to entrepreneurship course from UNIZG-R

Has deep understanding of 'Social License to Operate', how to implement environmental and social best practices	Covered within the Environmental management course of WUST

- Social tasks and performance

Table 8: First suggested improvements and revision on the coverage of Social tasks and performance skills and competencies within the TIMREX MSc programme towards better skills coverage.

Skills / Competencies	New or improved measures
Ability to work on problems with no clear answers	Can be covered with the EFG Exploration Internship Workshop with pre-prepared problems
Active learning and learning strategies	Can be covered with the EFG Exploration Internship
Shows adaptability, flexibility and self-reliance	Can be covered with the EFG Exploration Internship Group work
Is able to perform analytical thinking	Can be covered with the EFG Exploration Internship
Shows collaboration	Can be covered with the EFG Exploration Internship Group work
Shows creativity	Can be covered with the EFG Exploration Internship Covered within the Digital mine course of WUST
Shows emotional intelligence, empathy and connection with others	Can be covered with the EFG Exploration Internship

Is able to work remotely without losing focus	Can be covered with the EFG Exploration Internship
Setting priorities (goal setting) and focusing on goals, Defining a vision, Developing a strategy, Identifying strategic partners	Can be covered with the EFG Exploration Internship
Can find solution-oriented approaches to problems	Can be covered with the EFG Exploration Internship
Ability to look for new opportunities	Workshop on searching appropriate calls and tenders
Envisioning	Can be covered with seminar assignments or practical tasks. + Thesis work
Has good listening skills	Solve the (practical) problem after the discussion with professional from mining industry
Shows motivation and perseverance	Student can be tutor for other/younger students
Is oriented towards quality outputs	Student can be tutor for other/younger students
Reasoning and ideation	Student can be tutor for other/younger students
Teaching and training others	Student can be tutor for other/younger students
Values ideas of the self and others	Writing reviews of other project works or scientific articles + self evaluation

Ability to work different personalities, emotional makeups, viewpoints, specialties, educational backgrounds, and abilities, including with people one does not like	The experience of studying in an intercultural, international student group in different countries
Can do conflict resolution (open minded — answer may lie in the conflict space)	The experience of studying in an intercultural, international student group in different countries Covered within the Project management, appraisal and risk evaluation course of WUST
Is aware of cultural interactions, cultural literacy, emotional literacy, learning styles, awareness of implicit bias	The experience of studying in an intercultural, international student group in different countries

The revision of the skills and competencies with the above mentioned updates and suggestions, leads to a better skills and competencies coverage of the TIMREX MSc and its courses. Complementing the specific actions proposed in the above tables, a few transversal actions that can help to deliver a wide range of skills and competencies throughout the five sub-areas (overall proposed solutions) were also provided by the partners. These solutions are to also be considered and integrated into the curricula planning:

- Make more use of internships in and outside of the TIMREX consortium, but with a focus on industry relevant internships (partners working in mineral exploration).
- Extend the use of field work and technical visits to laboratories and the working places of TIMREX non-academic partners, with the possibility of visits to partners outside of the consortium to complement learning needs on data and innovative technologies and techniques in mineral exploration.
- Students should be given tasks/assignments on solving specific industry problems, which can be used within or outside the classroom.
- Make more use of group work and exercises with presentations and discussions as part of the academic teaching methodologies.
- Consider the possibilities to have students writing articles in any kind of media: magazines, scientific periodicals or on the web (e.g., geoscientific blogs).

- Students could attend seminars or presentations made by relevant stakeholders on topics related to the MSc. For all parties, including student it would be very beneficial if he/she is able to prepare a scientific paper during the study – connected with thesis or project work.
- Students could attend training courses / seminars / conferences on topics related to the MSc and should be encouraged to present their work actively (especially when connected to a Masters Thesis).
- Consider the integration of the students and their studies into innovation projects (e.g. at national or EU level, with different degree of international collaboration, on different points of the value chain, etc.), including incorporation of students into EU projects or Scientific projects – in all phases – from searching the right Call and Project frameworks, to proposal preparation, until the project implementation.
- Participation of students in national, European and international challenges such as Hackathons should be fostered.
- Attendance of MOOCs on topics that support the implementation of the MSc and where the academic partners might have identified gaps in skills and competencies (e.g. business and soft-related skills and competencies).
- Development of a tailor-made Social Sciences and Humanities-related course that can be incorporated in the TIMREX study programme.
- Encouraging students to be members of different nationally and internationally oriented professional organizations for networking via these channels.
- Participation of students at summer schools and similar events (not counting with the TIMREX Summer School, which already fits this criteria).
- Encourage the MSc students to also make use of Erasmus(+) for strengthening their skills and competencies.
- Use the public results and outputs of other projects. A good example is the acceleration programme of the TrainESEE project.
- Extend the mentoring offers besides the EFG Entrepreneurship mentoring to non-academic partners outside of the consortium.

These are a list of solutions that can be implemented during TIMREX to build on the MSc programme and support the deliverance of the necessary skills and competencies. They can either totally cover gaps or support already existing actions. As can be identified, most of the actions presented can be easily integrated into any academic planning.

7. The TIMREX Roadmaps

In this chapter, two types of roadmaps are presented: an overall roadmap for the TIMREX project (years 2022 to 2024) and one roadmap for the TIMREX programme as a future continuous effort (from 2025 onwards). While the first, focus on actions and timelines for a best-fitted MSc planning, the second focus on the MSc Double Degree implementation and continuous improvement. Due to the nature of the roadmaps, a few suggestions and conclusions span both roadmaps.

The TIMREX project, as an EIT RawMaterials-funded Education project, is running between January 2022 and December 2024. However, the plan is to continue using the TIMREX brand with the EIT Label going forward, leading to the TIMREX programme for the period after 2024. Therefore, for the overall TIMREX Roadmap we define two major timelines: 2022-2024 and 2025-2027, which are interconnected.

7.1 The TIMREX project Roadmap for Innovation and Entrepreneurship-related skills and competencies deliverance - Period 2022-2024 actions

During this period TIMREX runs two types of MSc: starting with a Joint Degree and ending in a first iteration of the Double Degree format. The first TIMREX cohort will start in the Fall of 2023, a first iteration of the TIMREX-based MSc. For the Joint degree, academic partners are making use of current teaching planning (coming from existing MSc courses) supported by non-academic partners that contribute to the curricula by providing webinars, talks, possibilities for internships and Masters' thesis, and others. The main aspects that separates this iteration of TIMREX from other MSc programmes are the focus on Innovation and Entrepreneurship skills and the involvement of non-academic partners in the learning process. Main actions to develop TIMREX during this period include:

- Monitor and classify the response of students to the current academic practices and their response to activities supported by the non-academic partners as defined in the curricula. Taking into account feedback and reactions of students, the TIMREX academic pathways could be adapted to accommodate changes that better suit the students. Other good source of content feedback for curricula improvement are the non-academic partners themselves as well as the industry.
- Monitor, analyse and select the current and future trends affecting or that might affect the mineral exploration industry, and devise a plan to integrate those into the curricula of the future TIMREX iterations. This step can be done with the support of foresight-looking exercises such as Focus Groups or Delphi Surveys, by involving experts in data collection and by analysing strategic documents issued by the raw materials sector entities.

- **Envisage new ways of delivering skills and competencies** not yet planned or adapt current ones. For example, the use of practical exercises and visual aids can become essential tools for active learning. Practical experience, especially with the support of non-academic partners through visits and internships should be extensively used. Finally, motivational tools such as financial rewards, real work experience, or frequent feedback, can greatly contribute to consolidate the learning process of students.
- **Provide networking opportunities to students**. TIMREX already plans guest lectures, networking events and mentoring schemes as part of the curricula, but these can prove essential to help students to build a network of professional connections and to contextualise course content and demonstrate how classroom material can be applied. A good source of networking can be provided with the help of the EIT RawMaterials Alumni, which the TIMREX project should engage with.
- **TIMREX needs to brand itself as a unique MSc mineral exploration-focused programme**. Support for this can be achieved with the branding of an equal opportunity program that has the EIT Label. Digital and physical representation of the project is essential to achieve the best results.

During this period, the TIMREX roadmaps for implementation look like (Figures 3 and Figure 4):

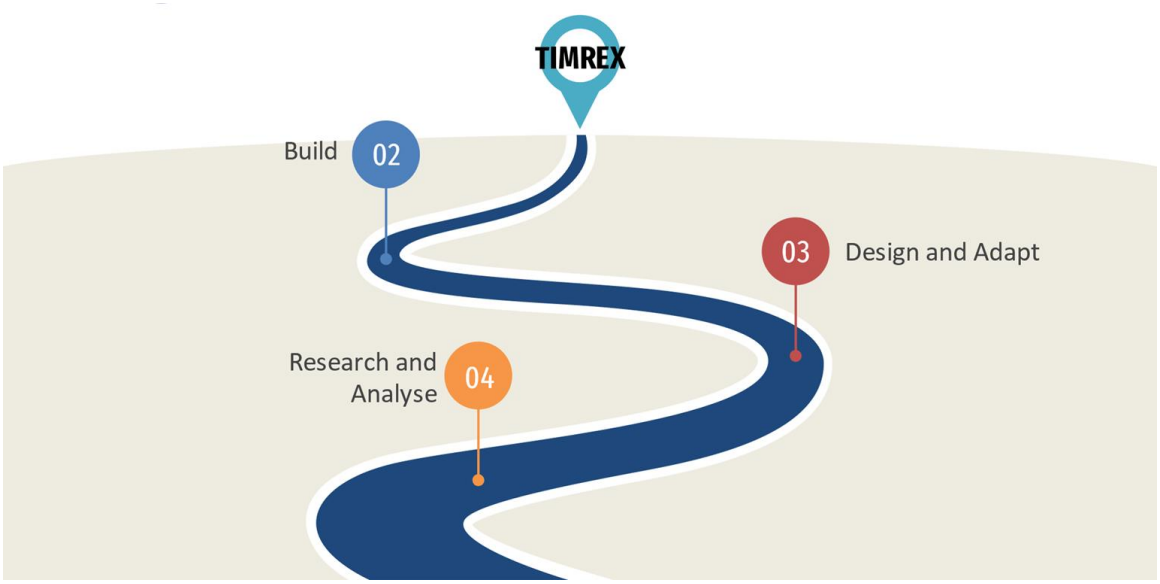

Figure 3: Simple action roadmap guiding the implementation principles for the TIMREX project.

TIMREX Roadmap 2022-2024

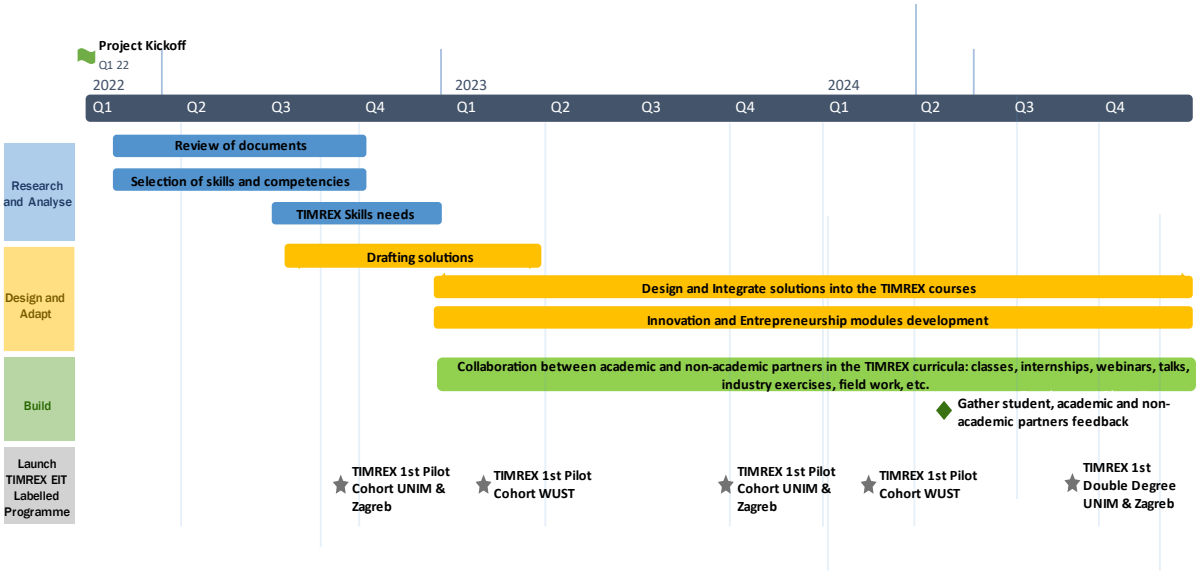

Figure 4: Roadmap with timeline and actions for TIMREX development in the period 2022-2024.

At first, the TIMREX consortium studies and analyses the raw materials sector skills and competencies offers, needs and gaps (as described in D4.1 and this document) and, based on that, identifies skills and competencies that are important to be covered with the MSc courses (see chapter 5 of this document). As a second step, the academic partners, supported by the non-academic partners, formulate design changes and adaptations to the curricula to strengthen the teaching and learning of necessary skills and competencies, and implement those into the teaching and curricula (as suggested in Chapter 6 of this document). The third step assumes joint efforts in building improved MSc curricula, up-to-date with the supply and demand of raw materials professions and its industry, and roll out and implementation of this unique course. These efforts will lead to the implementation of the first official TIMREX Double Degree offered by TIMREX for the academic years of 2024-2025 and its continuation after this EIT-funded project period.

7.2 The TIMREX project Roadmap for Innovation and Entrepreneurship-related skills and competencies deliverance - Period 2025-2027 and beyond actions

After the TIMREX Double Degree starts, it is important to continue the improvement of the MSc. A few actions to be taken into account for this purpose, which should be complemented with the actions identified for the previous years, include:

- Consider integrating more complementary methods outside of compulsory education to the TIMREX MSc programme in the case that the education raw materials system in general resists the change that is being advanced by TIMREX (as well as other MSc where involvement of non-academic partners is the new rule). Professional training (different from an internship) in industry partners and lifelong learning activities can contribute with skills and competencies that formal education cannot reach. TIMREX could extend its partnership network to achieve this goal.
- Continuous monitoring of skills and competencies. Academic partners could follow up-to-date in the raw materials sector by taking into account EU-funded projects and news, as well as strategic documents developed by EU and European institutions (such as EIT RawMaterials) and by hosting meetings with representatives of the raw materials industry. This action should be done on a yearly or biyearly basis for best results and could be done with the support of EIT RawMaterials. These meetings should consist of industry partners naming the skills and competencies they see as mostly needed.
- Extend the academic and non-academic partners of the TIMREX core, besides the current scope of the partnership. While more academic partners will help the TIMREX MSc to reach more students throughout Europe, the involvement of more non-academic partners will allow more and different skills and competencies to be covered, helping TIMREX to reach a bigger array of skills and competencies needs. Partners from other countries would be ideal to extend the geographical and cultural representation of TIMREX. A good source of academic-focused partnering institutions can be found on the INTERMIN Portal (https://portal.interminproject.org/) with its Mining Studies Network of potential partners. A useful source for non-academic partners is in the EIT RawMaterials members base itself. Industry partners, in particular, should be continuously engaged and be involved in the development of the curricula, while contributing to skills and competencies development to support learning.

- Combine the skills and competencies development offered within the TIMREX curricula with skills and competencies certificates (issued by TIMREX, EIT RawMaterials or other body) and referral letters (signed by academic and non-academic partners). Added value to students could also be provided under workshops and seminars about job opportunities in the raw

materials sector, besides the natural fit of exploration companies, thus extending the possibilities of employment.

- Academic partners will need to analyse and consider personalised learning, mentorship, collaboration and informal learning as main components of the learning process for students. These will require that academic staff is trained in order to be able to exploit resources and tools to support tailor-made learning pathways and experiences.
- Academic partners should pay attention to changing pedagogies, assessment strategies and curricula, and be able to respond more flexibly to individual learners' needs and changing labour market requirements.
- Social entrepreneurship is a trend on the rise and part of its skills and competencies are interlinked with entrepreneurial and intrapreneurial skills. Focus on the social entrepreneurship aspects can provide entrepreneurs with new ideas to support the raw materials sector (e.g. support to local stakeholder communities, support to SLO).
- TIMREX should not deviate from the two main components of teaching: tying technical skills with soft skills development. There should be a good balance for both types of skills. The future demands more individuals who are collaborative, innovative, system-thinkers who can manage complexity and see the interconnectedness and improvements across the value chain.
- TIMREX should focus on its mobility features and extend that mobility with the support of new academic and non-academic partners, including members from the knowledge triangle (education-research-industry), but also NGOs and communities. Mobility should therefore be consideres both on the academic-academic level and academic-non-academic level as well.
- TIMREX should promote job shadowing (on-the-job training and a learning opportunity for students by following and learning from a professional) towards non-academic partners both within and outside of the TIMREX spectrum. Job shadowing could provide the exact skills that will be needed in the industry to students.
- TIMREX partners should adjudicate for national and EU-based policies that support collaboration between universities, research centres and industry. This is a step that would entail collaboration with other institutions and bodies, since it would require a joint effort.
- TIMREX should search and secure new ways of funding to continue implementing its MSc programme. National and supra-national funding are both valuable options, as would be private funding from industry partners, in exchange for future workforce.
- Keep the T-shaped approach as the brand of the TIMREX programme. TIMREX is one of the new best-examples in the raw materials education field, in that it uses a T-shaped approach

in its teaching methodology. This unique feature should continue to be applied to grant the MSc with a good name to students, and to possible partners.

The TIMREX roadmap for the years 2025-2027 (and for any period after that) should look like the following (Figure 5):

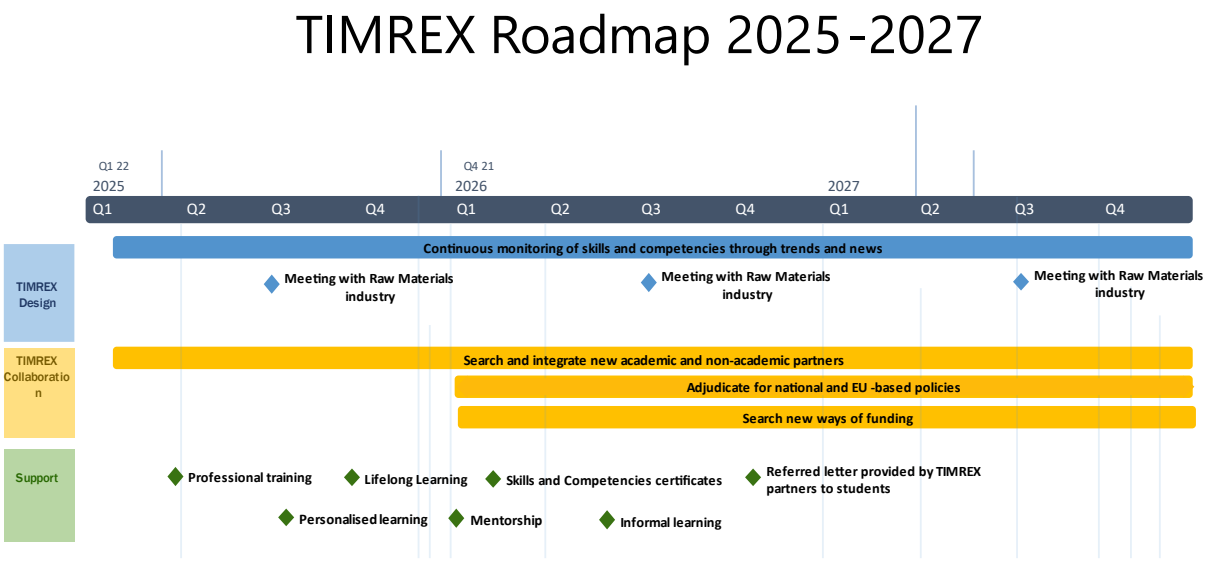

Figure 5: Roadmap with timeline and actions for TIMREX development in the period 2025-2027.

One of the first steps to improve TIMREX after the funding period is to secure new partnerships with academic and non-academic partners alike. At the same time, TIMREX shall start to monitor trends and advances in raw materials and mineral exploration and consider those to adapt its curricula – meetings with industry will be an essential part of learning about new developments. To grant continuation of TIMREX, new ways of funding should be obtained, and there should be a push towards influencing policies that better serve the interests of the mineral exploration/education symbiosis. As support measures, TIMREX needs to update its MSc with different actions such as inclusion of Professional training, Informal learning or by providing skills and competencies certificates to students.

8. Relation of the Roadmap for skills and competences to the achievement of KPIs

The implementation of the TIMREX project considers both EIT Core KPIs as well as KIC specific KPIs, for a total of six different KPIs.

For the EIT Core KPIs, the following measurable targets are considered:

1) EITHE05.1: Startups created by students enrolled & graduates from EIT-labelled programs. This KPI measures the "number of start-ups established in year N by students enrolled and graduates from EIT labelled MSc and PhD programmes or by learners/participants in other EIT labelled activities".
    a. Relation and contribution of this deliverable to EITHE05.1: A few aspects that are part of the TIMREX curricula are deemed to contribute to the creation of start-ups. These include the focus on current and future trends in the raw materials sector and adapted and future proof skills and competencies (including business-related competencies such as how to create and run a start-up) obtained within the TIMREX activities.
    b. Especially, the entrepreneurship-related skills and competencies that students will acquire during TIMREX through different actions (e.g. classes, mentoring, internships, development of business plans) will allow students to have the knowledge and part of the tools to create their own startups.

2) EITHE07.1: Graduates from EIT-labelled programmes. This KPI measures the "Sum of graduates from EIT labelled master's, PhD programmes and other education activities awarded EIT Label (in year N).".
    a. Relation and contribution of this deliverable to EITHE07.1: Innovation and Entrepreneurship concepts are essential part of the TIMREX EIT Labelled programme, and thus are mandatory for each student to complete courses and be exposed to them. This deliverable, therefore, contributes to a small part of the whole of TIMREX, as a whole, that will contribute to having graduates from the programme.

3) EITHE09.1 (21-22): Students and graduates from EIT labelled MSc and PhD programmes who joined start-ups. This KPI measures the "Number of students (per country) who joined start-ups during their EIT Label MSc and PhD studies. Sum of EIT Label graduates who joined start-ups up to 3 years after graduation."

a. Relation and contribution of this deliverable to EITHE09.1: The TIMREX Roadmaps for project implementation highly consider the integration of its students in research and industrial context thanks to activities such as mentoring by industry stakeholders, internships within raw materials companies or scholarships via the RIS Internship programme.
b. The focus on Innovation – greatly linked with the concept of startups – and on entrepreneurship – linked to the creation, nurturing and development of companies -, will also contribute to giving students the knowledge and interest in joining innovative startups in the raw materials field. A few actions presented in the roadmaps consider these aspects in their implementation: 1) Preparation of a business plan/idea as part of a course, 2) having companies presenting on the industry's future, needs, requirements, and lessons learned from the past, with the possibility of questions and answers sessions, 3) the TIMREX summer school, 4) participation in field missions (under the scope of ongoing projects and activities), 5) participation in national and international projects, and 6) Participation of students in national, European and international challenges; e.g., PDAC Next generation explorers Award challenge, SEG Evolve challenge.
c. The roadmap with timeline and actions for TIMREX development in the period 2025-2027, which includes actions such as meeting with the raw materials industry further contributes to the achievement of this KPI.

For the KIC Specific KPIs, the following measurable targets are considered:

1) KICN01-11: Improve gender balance in the RM sector. This KPI measures the "Relative number (value between 0 and 1) of women graduating from courses that are related to raw materials (incl. summer schools, individual courses, lifelong learning, PhD & Master EIT labelled programs)".
    a. Relation and contribution of this deliverable to KICN01-11: The innovation and entrepreneurship strategy and its actions (e.g. internships, mentoring, etc.) are designed to consider the inclusion of more women in TIMREX activities. This will anchor women in the raw materials-related education and raw materials sector activities, thus contributing to improving gender balance in the raw materials sector.
    b. Entrepreneurial-related actions are even more important in this sense, since creation and running of raw materials companies can be easily done by women (instead of a more physically demanding mining job), further guaranteeing the achievement of this KPI.
    c.

2) KICN02-07: Students in Master Education short courses. This KPI measures the "Number of MSc students that completed a RM-related short courses (Summer school, winter school, individual courses, etc.)".
    a. Relation and contribution of this deliverable to KICN02-07: Innovation and Entrepreneurship are main components of the TIMREX Summer School. They contribute to students in the TIMREX Masters to complete this action.

3) KICN02-10: Students & Industry - Knowledge Triangle Integration. This KPI measures the "Number of students exposed to industry as part of a KAVA project (participating in upscaling projects, doing internships for a project, in open innovation events, etc.)".
    a. Relation and contribution of this deliverable to KICN02-10: The roadmaps consider the implementation of actions that directly involve industry and research partners from the raw materials sector in the teaching and learning process of TIMREX. This integration of students into the Knowledge Triangle will be facilitated with the support of activities which include mentoring by industry experts, internships at research and industry partners and participation in national and international projects offered by the universities, research centres and industry. These, as well as other actions envisaged in the roadmap, will guarantee that TIMREX students are exposed to industry, especially focused on mineral exploration aspects, but not limited to them and thus reaching other parts of the raw materials value chain.

9. Conclusions

During Task 4.2 - Stock of current and future needed and offered modules for education, Innovation and Entrepreneurship-related skills and competencies offers and needs were studied, coupled with current and future trends in education and in the raw materials sector. Most relevant skills and competencies, according to these current and future needs were selected and matched against the planned offers of the TIMREX Masters programme. The analysis of such matching exercises uncovered the needs to supplement the Masters curricula with new or adapted actions to cover the identified gaps. To that end, two main roadmaps, focused on actions and a timeline, are suggested to support the implementation and development of TIMREX by academic and non-academic partners alike.

The skills and competencies that were selected are the most relevant specific skills to be acquired by students within the TIMREX framework, as seen by the partners views. Not all the identified skills have the same level of relevance, and, therefore, the TIMREX partners are free to choose and adapt the skills and competencies offers to the current possible actions and most pressing needs of the MSc programme. Innovation and Entrepreneurship relevant skills and competencies will be further considered for implementation under Task 4.3 and Task 4.4, where the consortium will define and create innovation and entrepreneurship modules that will help to deliver the best-fitted and selected skills and competencies.

References

Bartha, Z., Szép, T., Lipták, K. and Szendi, D. (2022). Entrepreneurship in the Raw Materials Sector. PROCEEDINGS OF THE LIMBRA INTERNATIONAL SCIENTIFIC CONFERENCE. 183 pp.

Correia, V. (2021). JOINT TRAINING PROGRAMMES FOR THE RAW MATERIALS SECTOR. INTERMIN D3.5. 39 pp.

Correia, V., Keane, C. and Evans, R. (2021). ACTION PLAN TO CLOSE SKILL GAPS AND ENHANCE EXISTING EDUCATION AND TRAINING PROGRAMMES. INTERMIN D3.4. 48 pp.

Correia, V., Sánchez, A. and Fernandez, I. (2019). INTERNATIONAL QUALIFICATION FRAMEWORK FOR THE RAW MATERIALS SECTOR. INTERMIN D3.1. 70 pp.

Correia, V., Sánchez, A. and Fernandez, I. (2019). REPORT ON TAILORED METRICS AND REFERENCE POINTS FOR QUALITY ASSURANCE AND INTERNATIONAL RECOGNITION OF TRAINING ON RAW MATERIALS RELATED TOPICS. INTERMIN D3.2. 55 pp.

Edelbro, C., Hulthén, E., Clausen, E., Tanner. D., Herrera Herbert, J., Jonsson. K., Bealieu, S., Kamp, A. and Försth, M. (2017). EUROPEAN INITIATIVE ON CDIO IN RAW MATERIAL PROGRAMMES. 9 pp.

Esparza, D., Lynch-Arroyo, R. and Olimpo, J. (2022). Empowering Current and Future Educators: Using a Scalable Action Research Module as a Mechanism to Promote High-Quality Teaching and Learning in STEM. Front. Educ. 6:754097.

European Commission (2016). A NEW SKILLS AGENDA FOR EUROPE - Working together to strengthen human capital, employability and competitiveness. COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS. 18 pp.

European Commission (2020). EUROPEAN SKILLS AGENDA FOR SUSTAINABLE COMPETITIVENESS, SOCIAL FAIRNESS AND RESILIENCE. 23 pp.

EY (2019). The Future of Work: the Changing Skills Landscape for Miners. 38 pp.

Hartlieb, P. and Wenighofer, R. (2019). DATABASE AND WEB INTERFACE. INTERMIN D 1.3. 8 pp.

Hartlieb, P. and Wenighofer, R. (2019). DATABASE PROCESS MANUAL. INTERMIN D 1.2. 47 pp.

Hartlieb, P., Jorda Bordehore, L., Regueiro y González-Barros, M., Correia, V. and Vidovic, J. (2020). A comprehensive skills catalogue for the raw materials sector and the structure of raw materials education worldwide, Mining Technology, 129:2, p. 82-94.

Herrera Herbert, J., Edelbro, C., Hulthén, E., Bhadani, K., Clausen, E., Tanner, D., Jonsson, K., Bealieu, S., Kamp, A. and Försth, M. (2017). IMPLEMENTATION OF CDIO INITIATIVE IN NEW EUROPEAN EDUCATION PROGRAMS IN RAW MATERIALS. Proceedings of EDULEARN17 Conference. 9 pp.

Herrmann, C. and Kara, S. (2019). Enhancing Future Skills and Entrepreneurship. 281 pp.
Holz-Clause, M., Guntuku, D., Koundinya, V., Clause, R. and Singh, K. (2015). Current and Future Trends in Higher Education Learning: Implications for Curriculum Design and Delivery. 19 pp.

Konrat Martins, M. and Bodo, B. (2019). Report on Skill Gaps, INTERMIN Deliverable 2.1. 99 pp.

Konrat Martins, M. and Bodo, B. (2019). ROADMAP ON SKILLS PROVISIONING FOR THE RAW MATERIALS SECTOR, INTERMIN Deliverable 2.3. 15 pp.

Konrat Martins, M., Bodo, B., Vagner, A. and Lamblin, V. (2019). INTEGRATED COMPETENCY MODEL FOR EMPLOYMENT ACROSS THE RAW MATERIALS SECTOR, INTERMIN Deliverable 2.2. 83 pp.

Meller, P. and Salinas, B. (2019). Revolución Tecnológica 4.0 y Capital Humano - Una Mirada desde la Minería. 48 pp.

Mosher, S. and Keane, C. (2021). VISION AND CHANGE IN THE GEOSCIENCES: The Future of Undergraduate Geoscience Education. 184 pp.

OECD (2018). Future of Education and Skills 2030: Conceptual Learning Framework: A Literature Summary for Research on the Transfer of Learning. 29 pp.

OECD (2018). The future of education and skills Education 2030. 23 pp.

Pacher, C., Murphy, M., Rauch, E., Adam, K., Valakas, G., Modis, K. and Pierer., R. (2021). Virtual E-Learning Community Hub – For Higher Education in the Raw Materials Sector. Proceedings of the 11th Annual International Conference on Industrial Engineering and Operations Management. 9pp.

Ramírez Masferrer, J., Herrera Herbert, J. and Kindelan Echevarría, P. (2022). Innovative Development of Student Skills in Raw Materials Engineering Programs. U.Porto Journal of Engineering, 8:1 (2022) 23-33.

Redecker, C., Leis, M., Leendertse, M., Punie, Y., Gijsbers, G., Kirschner, P., Stoyanov, S., and Hoogveld, B. (2011). The Future of Learning: Preparing for Change. 97 pp.

Regueiro, M. and Jorda, L. (2018). SKILLS CATALOGUE FOR THE RAW MATERIALS SECTOR. INTERMIN 1.1. 44 pp.

Sand, A., Rosenkranz, J., Lund, C., Sandström, A. and Samuelsson, C. (2015). EDUCATION RELATED TO MINERAL RAW MATERIALS IN THE EUROPEAN UNION: FINAL REPORT ON SKILL SHORTAGES AND MEANS OF ADDRESSING THEM. COBALT Deliverable 3.3. 60 pp.

The Chronicle of Higher Education (2019). Responding to Work-Force Needs: Views on how colleges can partner with employers to teach students 21st-century skills. 24 pp.

World Bank Group (2019). The Changing Nature of Work. 151 pp.

Yaneva, E., Papaefthymiou, S., Daling, L., Šoštari´c, S.B. and Merta, I (2022). Rethinking Education in the Raw Materials Sector through Tailor-Made Teaching Methodologies. Mater. Proc. 2021, 5, 94.

Annex 1 - List of selected Skills and Competencies per sub-area

Data Skills and Competencies

- Is able to handle and analyze Big Data and large datasets, integrating multiple large datasets of different types and from different disciplines
- Knowledge on advanced/predictive data analytics, digital twinning and simulation modelling
- Coding abilities in database (e.g. SQL, Access), statistical (e.g. R, Statistica) and others (e.g. MATLAB)
- Has data and digital literacy skills in human-to-machine interface operations
- Demonstrates proficiency in using at least one mining software package (e.g. VULCAN, DESWIK, XPAC), 3D CAD software
- Is able to design and can do design thinking
- Is able to evaluate data, data quality, purpose of collecting data, begin with understanding of how data will answer question
- Has experience with authentic research and collection of new information
- Demonstrates proficiency in geoinformatics software (GIS, 3D modeling...)
- Makes predictions and problem solving with limited data
- Knows about operation monitoring and analysis
- Understands and is able to do real-time data analysis
- Knowledge and is able to do systems analysis and evaluation, systems evolution and systems thinking
- Proficiency in text, image and voice processing
- Understands and can implement the complex dependencies between data obtention, data processing, modelling and simulation
- Use of appropriate methods, reading and interpreting graphs
- Use of neural networks for data processing

Applications of technology in Mineral exploration Skills and Competencies

- Shows advanced systems development skills and integration to manage autonomous systems
- Knows about advances in robotics, automation, autonomous vehicles, remote equipment and artificial intelligence
- Knows about Augmented and Virtual reality
- Is technologically versatile (e.g., Google Earth, tablets, smartphones, apps)
- Knows about Blockchain and its application potential
- Knows about deep learning and machine learning
- General understanding of sustainability and materials & energy efficiency
- Has industry and research awareness
- Knowledge in designing technology on human terms
- Knowledge on mechatronics
- Shows and knows about new high tech production to drill deeper and in new environments and equipment management in these environments
- Knowledge on quantum computing
- Is able to repair mining technologies
- Knows about robotization and underwater exploration techniques, including seabed exploration, and underwater observations
- Knows about tech design, engineering, installation and maintenance
- Is able to use technology, monitor and control it
- Is able to use sensors and computers to collect data

Mineral exploration knowledge and techniques Skills and Competencies

- Knows about analytical chemistry with regards to various geological sampling techniques and how to apply these concepts to real world problem aired by others.
- Is able to approach complex geophysical problems in an innovative way by modeling and computer processed interpretation

- Knows about the potential of biotechnology for exploration
- Is able to characterize of the elemental composition of rocks – using XRF and other techniques
- Can acquire data (sensor positioning requiring on site learning) by satellite or drones and with UAVs
- Shows deep-water engineering skills for designing, implementing and operating deep sea mining projects
- Knows and can operate drones and drone photogrammetric studies
- Is aware of emerging techniques and technologies for extraction
- Is aware of innovative exploration technique development derived from research projects such as UNEXMIN, UNEXUP, ¡VAMOS!, or other projects related with geo-technologies, mineral and geological resources, or geo-exploration.
- Can do field work preparation, organization and implementation; Contemporary methods of surveying and conducting field geology
- Knowledge on fluid dynamics
- Knows how to couple geochemistry with environmental studies concerning environmental impact of mining
- Can do geological and structural mapping
- Can do geological model Design
- Is aware of geophysical research technics, Interpretation of the geophysical logs, downhole surveys
- Knows about geospatial analytics
- Knowledge in in situ measurements, sensor applications
- Knowledge of innovative exploration technologies; Portable spectroscopic techniques and their applicability and limitations (hyperspectral, XRF, LIBS, SWIR)
- Application of laboratory analytical techniques and their limitations
- Knowledge of materials extraction techniques and technologies
- Performs metallogenic studies, prospectively assessments and mineral exploration (metal, non-metal and energy)
- Knows about the mineral exploration for new frontier mining e.g. deep sea and space resources

- Knowledge on mining wastes and secondary raw materials analyses, including sampling
- Performs polishing and microscope techniques
- Practical knowledge on new exploration and geophysics methods, including IoT and machine learning tools.
- Knowledge on primary raw materials (metal, non-metal and energy) – composition and metallogenic factors
- Can perform SEM/EDS analyses of rock and environmental samples
- Knowledge on smart sensors
- Does soil, stream sediments and rock sampling for prospectivity assessments.
- Knowledge on the UNFC resource classification system

Business Management and Entrepreneurship Skills and Competencies

- Analyses the market to predict future demand/supply trends & Recognizes new business opportunities and developing those opportunities into new products and services
- Understands basics of entrepreneurship, value creation, idea generation, opportunities, accounting, finance, technology, marketing, risk (financial literacy)
- Is innovative and knows about innovation practices in mineral exploration
- Understands branding and networking
- Understands business, operating models and strategic planning
- Has deep understanding of 'Social License to Operate', how to implement environmental and social best practices
- Knowledge on core legal and economic concepts of a mineral resource projects from the operator's / entrepreneur's perspective
- Creates a business plan, a financial plan & is able to obtain financing, securing access to resources, to find cost effective technologies, to maximize revenue
- Knowledge on how to create and run a business
- Knowledge on development of green products, services and business models, and creation of innovative nature-based solutions
- Knowledge on developing and implementing risk management strategies and plans

- Knowledge on facilitating the implementation of environmental, engineering, mining and social best practices
- Is able to identify the significant cost areas related to the operation
- Is able to identify and frame education in terms of real business problems
- Understands the life cycle and the phases of a start-up company from the initial idea till a solidified company
- Knowledge on Intellectual Property Rights
- Can interrogate and interpret financial statements
- Knowledge of personal fit with being an entrepreneur / being entrepreneurial
- Knows how to manage contracts, contractors and consultants
- Can manage projects, organisations and teams. Shows leadership.
- Oversees the implementation of plans and risk management
- Prepares and manages budgets and assets & Allocates resources
- Knowledge about product/service commercialisation
- Is able to report outcomes and recommendations to relevant stakeholders
- Understands and applies business analysis techniques (e.g. 6 sigma, Lean Processes)
- Understands business development principles applicable to the mining industry
- Understands mine economics and the minerals market and their influence on mining systems
- Understands the basic KPI's used in mining (e.g. $ /oz etc.)
- Understands the impacts of commodity price fluctuations
- Understands the organisational, hierarchy and information flows for typical mining businesses and operations

Social tasks and performance Skills and competencies

- Ability to carry on an interactive dialogue
- Ability to look for new opportunities
- Ability to work on problems with no clear answers

- Ability to work with different personalities emotional makeups, viewpoints, specialties, educational backgrounds, and abilities, including with people one does not like
- Active learning and learning strategies
- Shows adaptability, flexibility and self-reliance
- Is able to perform analytical thinking
- Is a leader and follower
- Is quick to notice if there are any changes in people or a work/learning situation and is observant
- Shows collaboration
- Is able to perform in competitive environments
- Performs complex stakeholder analysis and engagement and shows interpersonal skills to reach across diverse stakeholder groups
- Can do conflict resolution (open minded — answer may lie in the conflict space)
- Is able to coordinate
- Copes with uncertainty, ambiguity, and risk
- Shows creativity
- Is aware of cultural interactions, cultural literacy, emotional literacy, learning styles, awareness of implicit bias
- Is curious
- Shows decision-support skills underpinned by capabilities in Data and Digital literacy and collaboration skills
- Has deeper understanding of the aspects and long-term implications of the Social Licence to Operate (SLO) process, including the role of external and internal stakeholders in achieving sustainable development goals by the mining sector
- Demonstrates a commitment to doing an effective job
- Is able to help others develop
- Shows motional intelligence, empathy and connection with others
- Envisioning
- Is aware and implements ethics, ethical awareness
- Has knowledge on foreign languages including English

- Shows a global perspective
- Is able to set goals
- Handling stress and rejection
- Has a good understanding of what other people need and endeavours to offer this
- Can communicate with investors and how to communicate with local community
- Can communicate with legislative bodies and how to transfer information to the industry and research
- Knows about potential conflicts related to the use of land and water by the project
- Is an information seeker
- Shows initiative and takes risks
- Applying skills in new scenarios (Intellectually flexible)
- Knows and describes Social Geology and Geopolitics
- Knowledge on how to write an appealing scientific paper and how to communicate science
- Learns through experience
- Has good listening skills
- Shows and implements logic
- Manages and apply concepts as a human right and gender equality
- Manages uncertainty in problem solving
- Mobilises others and resources
- Regularly checks whether work is on schedule (monitoring)
- Shows motivation and perseverance
- Can perform networking and is able to negotiate with others
- Performing under pressure - Stays in control of himself/herself in chaotic situations
- Is persistent
- Is able to convince and persuading others through speech
- Performs planning, organising and management tasks
- Is prepared for life-long learning; How to learn and use new technology
- Prepares documents and reports

- Has project and goal focus
- Knows and is able to implement project design, scheduling and management
- Can perform public speaking
- Is oriented towards quality outputs
- Shows good reading comprehension
- Reasoning and ideation
- Is able to work remotely without losing focus
- Is able to perform research and experiments
- Can implement scenario planning to enhance decision-making support and balanced decision making
- Shows self-awareness, self-efficacy, self-confidence and self-expression
- Setting priorities (goal setting) and focusing on goals, Defining a vision, Developing a strategy, Identifying strategic partners
- Knows and implements social entrepreneurship
- Has social perceptiveness and performance
- Can find solution-oriented approaches to problems
- Solves problems under pressure and adapt theory to practical physical problems
- Knows about sustainability and applies sustainable practices and thinking
- Teaching and training others
- Shows good teamwork
- Understands societal relevance
- Values ideas of the self and others
- Is versatile and adapts to different problems

Annex 2 – Samples of the matrixes used for skills and competencies coverage (Business As Usual)

Data Skills and Competencies

Skills & Competencies	Actions
Is able to **handle and analyze Big Data and large datasets, integrating multiple large datasets of different types and from different disciplines**	LTU-2 Exploration LTU-4 Geochemical exploration WUST-1 Computer Aided Geological Modelling and Geostatistics UNIZG-RGNF-5 Exploration geochemistry, 1st semester, routs 3, 4, 5 and 8 UNIZG-RGNF-7 GIS in Exploration of Mineral Resources, 1st semester, routs 3, 4, 5 and 8 UM-8 Data and information processing UM-28 Geostatistics UM 37 Geochemical prospecting methods GeoZS – GIC DP Internship
Knowledge on **advanced/predictive data analytics, digital twinning and simulation modelling**	WUST-13 Digital mine UM-23 Geophysical inversion
Coding abilities in **database (e.g. SQL, Access), statistical (e.g. R, Statistica) and others (e.g. MATLAB)**	UM-6 Computer sciences for engineers GeoZS – GIC DP Internship
Has **data and digital literacy skills in human-to-machine interface operations**	UM-25 Geophysical data processing UM-15 Geophysical interpretation and prospecting LTU-3 Mining geology LTU-4 Geochemical exploration WUST-1 Computer Aided Geological Modelling and Geostatistics WUST-13 Digital mine WUST-17 Operations research WUST18 Principles and Application of InSAR and GIS in mining UNIZG-RGNF-5 Exploration geochemistry, 1st semester, routs 3, 4, 5 and 8 UNIZG-RGNF-7 GIS in Exploration of Mineral Resources, 1st semester, routs 3, 4, 5 and 8 GeoZS – GIC DP Internship

Applications of technology in Mineral exploration Skills and Competencies

Skills & Competencies	Actions
Shows **advanced systems development skills and integration to manage autonomous systems**	Non-remunerated internship or academic internship at INESCTEC Research work for thesis, UGR, INESC TEC WUST-13 Digital mine
Knows about **advances in robotics, automation, autonomous vehicles, remote equipment and artificial intelligence**	Non-remunerated internship or academic internship at INESCTEC Research work for thesis, UGR, INESC TEC WUST-13 Digital mine
Knows about **Augmented and Virtual reality**	Non-remunerated internship or academic internship at INESCTEC Research work for thesis, UGR, INESC TEC WUST-13 Digital mine Internships at KGHM Cuprum for some students, if needed
Is **technologically versatile (e.g., Google Earth, tablets, smartphones, apps)**	LTU-5 Applied field exploration UM-35 Geological mapping UM-10 Structural geology UNIZG-RGNF-7 GIS in exploration of mineral resources, 1st semester, routs 3, 4, 5 and 8 UNIZG-RGNF-13 Field and laboratory practicum, 2nd semester, routs 3, 4, 5 and 8 WUST-13 Digital mine Internships at KGHM Cuprum for some students, if needed
Knows about **Blockchain and its application potential**	WUST-13 Digital mine
Knows about **deep learning and machine learning**	
General **understanding of sustainability and materials & energy efficiency**	UM-17 Legal and economic studies for mining and geology UNIZG-RGNF-26 Mineral Resources, Economics and the Environment, 4th semester, routs 3, 4, 5 and 8 WUST-14 Environmental management SOC internship as part of thesis work

Mineral exploration knowledge and techniques Skills and Competencies

Skills & Competencies	Actions
Knows about **analytical chemistry with regards to various geological sampling techniques and how to apply these concepts to real world problem aired by others.**	UM-37 Geochemical prospecting methods LTU-4 Geochemical exploration UNIZG-RGNF-5 Exploration geochemistry, 1st semester, routs 3, 4, 5 and 8 UNIZG-RGNF-11 Analytical methods in ore deposits, 2nd semester, routs 3, 4, 5 and 8 Internships at KGHM Cuprum for some students, if needed GeoZS – Min.res&Geochem. DP Internship
Is able to approach **complex geophysical problems in an innovative way by modeling and computer processed interpretation**	UM-15 Geophysical interpretation and prospecting UM-24 Geophysical exploration methods II. UNIZG-RGNF-12 Geophysical exploration of mineral resources, 2nd semester, routs 3, 4, 5 and 8 WUST-2 Engineering Geophysics GeoZS – Internship
Knows about the potential of **biotechnology for exploration**	
Is able to **characterize of the elemental composition of rocks – using XRF and other techniques**	UM-13 Analytical technics in mineralogy and petrology UNIZG-RGNF-11 Analytical methods in ore deposits, 2nd semester, routs 3, 4, 5 and 8 UNIZG-RGNF-13 Field and laboratory practicum, 2nd semester, routs 3, 4, 5 and 8 UNIZG-RGNF-17 Clay mineralogy, 3rd semester, routs 3, 4, 5 and 8 LTU-1 Senior design project in ore geology Internships at KGHM Cuprum for some students, if needed (including related field works) GeoZS – Internship
Can **acquire data (sensor positioning requiring on site learning) by satellite or drones and with UAVs**	LTU-2 Exploration WUST-18 Principles and Application of InSAR and GIS in mining UNIZG-RGNF-7 GIS in Exploration of Mineral Resources, 1st semester, routs 3, 4, 5 and 8 UM-5 Geodesy, spatial informatics Internships at KGHM Cuprum for some students, if needed (including related field works)
Shows **deep-water engineering skills for designing, implementing and operating deep sea mining projects**	Student research work supported by UGR, INESC TEC Non-remunerated internship or academic internship at INESCTEC

Business Management and Entrepreneurship Skills and Competencies

Skills & Competencies	Actions
Analyses the market to **predict future demand/supply trends** & **Recognizes new business opportunities and developing those opportunities into new products and services**	EFG Exploration Entrepreneurship, 3rd semester, all routes LTU-3 Mining geology, 3rd semester, WUST-5 Project management, appraisal and risk evaluation UNIZG-RGNF-26 Mineral resources, Economics and the Environment, 4rd semester, routs 3, 4, 5 and 8 UNIZG-RGNF-22 Introduction to entrepreneurship, 3rd semester, routs 3, 4, 5 and 8 UM-17 Legal and economic studies for mining and geology
Understands **basics of entrepreneurship, value creation, idea generation, opportunities, accounting, finance, technology, marketing, risk (financial literacy)**	UM-18 Strategic management WUST-5 Project management, appraisal and risk evaluation UNIZG-RGNF-22 Introduction to entrepreneurship, 3rd semester, routs 3, 4, 5 and 8 UNIZG-RGNF-26 Mineral resources, Economics and the Environment, 4rd semester, routs 3, 4, 5 and 8 EFG Exploration Entrepreneurship, 3rd semester, all routes
Is innovative and knows about **innovation practices in mineral exploration**	LTU-5 Applied field exploration, summer, all students Student research work as part of the thesis work UNIZG-RGNF-13 Field and laboratory practicum, 2nd semester, routs 3, 4, 5 and 8 UNIZG-RGNF-2 Mineral deposits Exploration, 1st semester, routs 3, 4, 5 and 8 UM-13 Analytical technics in mineralogy and petrology Internships at KGHM Cuprum for some students, if needed (including related field works)
Understands **branding and networking**	UM-16 Quality management EFG Exploration Entrepreneurship, 3rd semester, all routes
Understands **business, operating models and strategic planning**	UM-16 Quality management EFG Exploration Entrepreneurship, 3rd semester, all routes

Social tasks and performance Skills and competencies

Skills & Competencies	Actions
Ability to **carry on an interactive dialogue**	SOC internship EFG Exploration entrepreneurship
Ability to **look for new opportunities**	
Ability to **work on problems with no clear answers**	
Ability to **work with different personalities emotional makeups, viewpoints, specialties, educational backgrounds, and abilities, including with people one does not like**	SOC internship EFG Exploration entrepreneurship LTU-5 Applied field exploration Internship
Active learning and learning strategies	UM-13 Analytical technics in mineralogy and petrology UNIZG-RGNF-11 Analytical methods in ore deposits, 2nd semester, routs 3, 4, 5 and 8 LTU-2 Exploration LTU-4 Geochemical Exploration – IoGAS, LTU-3 Mining Geology – Geovia Surpac, UM-6 Computer Sciences for Engineers – MatLab, UM-37 Geochemical prospecting methods – QGIS, IoGAS, WUST-1 Computer Aided Geological Modelling and Geostatistics – Datamine, UNIZG-RGNF-7 GIS in Exploration of Mineral Resources – QGIS, ArcGIS, UNIZG-RGNF-3 Petroleum Geology – Petrel See answers to Qi2 pp 5-6
Shows **adaptability, flexibility and self-reliance**	
Is able to **perform analytical thinking**	Thesis work / thesis project
Is a leader and follower	EFG Exploration Entrepreneurship See OLO table, OLO 6
Is quick to notice if there are any changes in people or a work/learning situation and is observant	Internship SOC internship See OLO table OLO 4
Shows collaboration	
Is able to **perform in competitive environments**	See OLO table OLOs 1, 3