IMPROVING THE ENGINEERING EDUCATION IN THE RAW MATERIALS SECTOR IN AN ADVANCED, DECARBONISED, AND DIGITAL EUROPEAN SOCIETY

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ABSTRACT

The minerals industry is facing a changing talent landscape. With digitalization and a transition towards a decarbonized economy, a mining industry necessitating new skillsets and with technology cycles that are getting shorter and shorter, the new panorama is transmitting pressure in the need of trained workforce, and mining companies need to ensure that their boards and staffs are properly constituted to support the transformations that the sector is currently undergoing, including fluency in such areas as technology, integration, systems security, and cybersecurity.

In the raw materials sector, technology is not an end in itself. The greatest impact will come from embedding these technologies as an integrated whole and all across the mining value chain. The “New Industrial Strategy for Europe” (European Commission, 2020) addresses the twin challenge of the green and the digital transformation as both will require new technologies, with investment and innovation to match. Mining industry will create new products, services, markets, and business models, new types of jobs that do not yet exist, but which will need skills that students do not yet have. The breadth and depth, the scale and speed, the nature and necessity of the twin transitions are unprecedented. For this, the European industry cannot afford to simply adapt: it must now become the accelerator and enabler of change and innovation.

This paper describes the activities developed as part of the MEITIM Project with the support of EIT Raw Materials, one of the eight Knowledge and Innovation Communities (KICs) initiated by the EIT (European Institute of Innovation and Technology), funded by the European Commission, and whose mission is to help boost the competitiveness, growth, and attractiveness of the European raw materials sector through radical innovation and guided entrepreneurship. In this paper, the MEITIM conception and innovations are described, to show how three leading European Universities, with the help of EIT Raw Materials are shaping the way to help students to acquire and develop skills and knowledge addressed to this competitive environment, and become part of the highly-skilled workforce that the mining industry will require.

Keywords: Program development; Engineering studies; Innovation; Entrepreneurship skills; Mining; Future workforce

INTRODUCTION

The transformations that have taken place in Europe in recent years are only the prolegomena of the real revolution that is yet to come. The EU was one of the first signatories to the Kyoto Protocol in 1997 and subsequently to the Paris Agreement in
2015 among others. The *Paris Agreement* [1], the first universal and legally binding agreement to deal with the climate change global emergency, establishes a global framework to obligatorily reduce, as soon as possible and substantially with available technologies and current scientific knowledge, global greenhouse gas emissions to keep global warming well below 2 °C and continuing efforts to limit it to 1.5 °C. It is, therefore, a bridge between current policies and climate neutrality that must exist by the end of the century to prevent dangerous climate change with disastrous consequences and is the first of other more demanding agreements that are yet to come to achieve carbon dioxide neutrality.

In 2019 the European Commission published *The European Green Deal* [2], which is a concrete and executive action plan to promote the efficient use of resources by moving towards a clean and circular economy, restore biodiversity and reduce pollution. It was the first of a set of standards approved immediately afterward, but the important thing is that it is the roadmap to provide the EU with a truly sustainable economy, based on a growth strategy that transforms the Union into a modern, resource-efficient, and competitive economy, where net greenhouse gas emissions have ceased to occur in 2050, the economic growth is decoupled from resource use, and that transforms climate and environmental challenges into real opportunities.

In this line of action, but putting more pressure on its development, in December 2020, the EU presented its updated and improved Nationally Determined Contributions, aiming to reduce emissions by at least 55% by 2030 from 1990 levels, as well as information to facilitate clarity, transparency, and understanding of nationally determined contributions. Here, the EU and its Member States, acting together, have committed to reaching a binding net internal reduction target of at least 55% of greenhouse gas emissions by 2030 compared to 1990 levels. With this, the EU sets itself even more ambitious objectives than those that had been set in the Paris Agreement to reach a decarbonized economy.

**INTERNATIONAL TRANSFORMATION CONTEXT**

Society in general, with industry at the forefront, faces a series of challenges in this new international context in which diversification in clean energy generation and digitalization in all areas of industry and society will play a decisive role in how the economies produce and consume, and all this will highly increase the demand for mineral and materials components. Eliminating greenhouse gas emissions will mean having to significantly upgrade existing industrial facilities or replace them entirely. These investments will be part of the next industrial revolution. A modern, competitive, and prosperous industry in the EU, staying at the forefront of the transition, means having the possibility to strengthen its presence in a global economy that will inevitably have increasingly stringent carbon caps. In the short term, digitalization and automation are seen as some of the most promising and effective ways to increase competitiveness, and efficiency in the use of resources and reduce greenhouse gases emissions. Europe is currently in the midst of disruptive innovation in emerging green energy, electric mobility, and clean technology.

Strategic forecasting studies carried out by the European Commission clearly show that the demand for critical raw materials will increase very significantly, especially given the ongoing transition towards a green digital economy, where new technologies highly
depend on them. Estimates managed by the Commission show that by 2050, the growth of the EU will cause the demand for critical raw materials to multiply because mineral resources are the lifeblood of our modern society and the key to a more sustainable future.

In this new industry, mining and industrial processes require high connectivity between their components without giving up the basic requirements of business continuity and high availability. Therefore, it is necessary to create new intelligent manufacturing processes capable of better adapting to needs, production processes, and efficient resource allocation. Much of the value creation in mining will no longer be based on the efficiency of operations to move material, but rather on how well companies collect, analyze and react to real-time information to separate and transport material more efficiently [3].

The mining industry is confronted with many technological challenges along the entire production value chain. There is a need for innovative production solutions [4]. The evolution of computers, sensors, data analysis, and intelligence techniques will allow for the strengthening of the integration of automated processes within the mining industry. Therefore, it can be said that in the future mining will be almost robotized and operations will be largely remote. In this way, the optimization of processes will be done in offices with experts analyzing data and studying different models. In short, digitalization and automation will be increasingly relevant.

To be truly innovative, companies need a workforce with a culture that supports new ideas and new ways of doing business efforts but also executes those ideas. It’s a question of experimenting, piloting, learning, and adapting to developing solutions. Involving the workforce in any new technological developments through both on-the-job and classroom-based training can have a radical impact on the successful implementation of new strategies [5]. World-leading mining companies have embarked on substantial training programs to upskill their workforce to enable them to handle a rapidly changing operating environment [6].

MEITIM PROJECT

EIT Raw Materials is one of the eight Knowledge and Innovation Communities created to boost innovation and entrepreneurship across Europe with the support of the European Institute of Innovation and Technology (EIT). Created in 2015 and participated by more than 120 European partners from leading industries, universities, and research institutions from more than 20 EU countries, EIT Raw Materials is the largest consortium in the raw materials sector worldwide. Its partners are active across the entire raw materials value chain, from sustainable exploration, efficient mining, and mineral processing to substitution, recycling, and circular economy. It has the vision of developing raw materials into a major strength for Europe by finding new, innovative solutions to secure supply and improve the raw materials sector in Europe and the mission of contributing to boosting competitiveness, growth, and attractiveness of the European raw materials sector via radical innovation, new educational approaches, and guided entrepreneurship [12].
The Raw Materials Academy is the overarching brand of all the educational activities of the EIT Raw Materials. Activities across the entire ecosystem of learners (Ph.D. students, masters’ students, industrial partners, professionals within the raw materials sector, and wider society) foster new ways of learning and teaching by connecting academia, industry, and research organizations. EIT Raw Materials will educate people that will have an intra- and entrepreneurial mindset and will be 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.

Digitization and automation are two primary objectives that the industry is focusing on, as are how to implement concepts like Industry 4.0, technology integration, smart mines, etc. A survey developed in the MEITIM Project revealed that no MSc program in technology integration exists for the development of professionals with expertise in technology integration and innovation needed by the industry. There are many initiatives regarding different technologies and their mining application, but nothing regarding how to focus on this issue from a strategical point of view of a company, converting this integration into a competitive issue [7].

To keep its competitive advantage and differentiation with the rest of the economies, the EU needs to increase significantly the large-scale deployment and demonstration of new technologies across sectors and the single market, building new innovative value chains. Being competitive requires the right conditions for entrepreneurs to turn their ideas into actions and for companies of all sizes to thrive and grow [9].

A competitive industry depends on recruiting and retaining a qualified workforce. Pro-active re-skilling and upskilling are necessary to reap the benefits of the ecological transition. As the twin transitions gather speed, Europe will need to ensure that
education and training keep pace. Making lifelong learning a reality for all will become all the more important: in the next five years alone, 120 million Europeans will have to upskill or reskill.

This reflects the importance of skills for the twin transitions and the opportunities they can create for people. Moving to a low-carbon economy is expected to create more than 1 million jobs by 2030, while there are already currently 1 million vacancies in Europe for digital technology experts. At the same time, 70% of companies report that they are delaying investments because they cannot find the people with the right skills [9].

Supported by the EIT Raw Materials through the Raw Materials Academy, the first international Master's program in Entrepreneurship, Innovation, and Technology Integration in Mining (MEITIM) is being developed (http://www.meitim.eu) to fill this gap. This MSc level program [8] will be oriented to:

- Enhance the creativity and innovation capacity of engineers.
- Provide in-depth knowledge of technologies (by practical training) that are entering the primary sector of the raw materials value chain (geology, mining, mineral processing, and metallurgy). This will give them the ability to understand the technical, business, social and economic aspects, as well as giving them a broad understanding of innovation and entrepreneurship in the raw materials sector.
- Stimulate technological innovation and technology integration with the vision of creating new opportunities and added value.
- Improve the mindset of entrepreneurship.
- Expand the KIC community of professionals in this dynamic and innovative activity sector.
- Complement the T-Shape profile of professionals trained.

By achieving all this, the program will train the engineers that can successfully develop the technology integration projects that currently are taking place in the raw materials sector.
MEITIM is committed to educational excellence through a strong student-focused educational experience and to provide quality education with contemporary and highly professional curricula. To achieve this objective, MEITIM has undergone thorough the conception and design of a new curriculum. This project started beginning in January 2020 and will finish ending December 2023. It is being developed by a consortium coordinated by Universidad Politécnica de Madrid (Technical University of Madrid) from Spain and constituted by Agencia Estatal Consejo Superior de Investigaciones Científicas, CSIC (Spanish National Research Council) from Spain, Atlantic Copper S.A.U. (Spain), Geologian tutkimuskeskus, GTK (Geological Survey of Finland), Lappeenranta University of Technology from Finland, Metso Minerals Oy (Finland), Outotec (Finland) Oy, Politechnika Wrocławska (Wroclaw University of Science and Technology, WUST) from Poland and Suomen Malmijalostus Oy (formerly Terrafame Group Oy) from Finland.

The technological and societal challenges of the 21st century are profound and wide-ranging. The demands for sustainable development will require redefined and innovative engineering talent and leadership. The emergence of a connected,
competitive, and entrepreneurial global economy, in which successful engineers increasingly need technical competency and professional skills that differ from what worked in the past. These reasons build up a clear case for a disruptive definition of new curricula. Based on this, the objective of the project is to define a novel instructional paradigm and content plan in a full 120 ECTS program to address modern demands of professional education (as outlined above) [9].

Universities participating in the MEITIM consortium have proven experience in the design and implementation of new university degrees and have the capacity and the means to implement by their own a similar degree. MEITIM's great competitive advantage is the realization of the possibility that the program is international, business-oriented, and designed from a business perspective and its needs.

Another competitive advantage that must be recognized is the fact that the design principles of the MEITIM program are focused on achieving the different international accreditations like EIT Label, ABET, and EurACE in the shortest possible time. This will reinforce the position of the program in the academic global offer, increasing the interest and possibilities of bringing a greater number of brilliant students from very different nationalities and backgrounds.

Finally, it is worth noting the established approach of attracting students from very different fields, with special emphasis on students from RIS countries. During the development of the work, it has been evident the possibilities and interest that a program like MEITIM can also have for disabled students.

Higher education has been evolving rapidly to respond to fast-changing demands. Overall, Europeans are becoming better educated, as more students have the opportunity to develop the high-level skills and knowledge that our societies require. Thanks to the Bologna Process and the Erasmus+ program, students have become more mobile and can benefit from study and employment opportunities abroad.

The European Higher Education Area (EHEA) landscape highlights Europe’s potential to set high standards for modern and relevant educational provision. The Bologna Process has not only inspired change within European higher education but also across other world regions. This is important to recognize, as today, more than ever, Europeans have to embrace an increasingly complex and inter-connected global reality. The vision for 2025 is of a Europe in which learning, studying, and doing research will not be hampered by borders and in which people have a strong sense of their identity as Europeans.

THE MINING INDUSTRY MARKET NEED

For the mining sector, innovation can take many forms: core innovations that optimize existing assets, products, or services; adjacent innovations that incrementally expand a business in new areas; transformational innovations that represent breakthroughs and inventions for the industry, etc. Innovation is not just continuous improvement, nor is restricted to technology and changes in the way that companies mine: it also applies to a company’s operating structure, management, communications strategies, stakeholder engagement, and several other areas central to the business. It represents a viable conduit for the mining sector to increasingly develop and implement new approaches, technologies, and processes to realize mineral resource opportunities while improving environmental performance and meeting social expectations. There are several drivers
of innovation in the mining sector: above all, companies need to remain competitive, improve the productivity of their assets; reduce their operational risks; increase the efficiency of deposit discovery; strengthen their mineral recovery rates; recover metals and minerals of higher quality; and drive their growth. In addition, with recent commodity price declines and reduced profit margins, there is an urgent need for many companies to reduce the costs of developing deposits and operating mines, in terms of labor, capital, energy, and other expenses. Also, as new, significant deposits become increasingly remote, deep, and difficult to access, new innovative approaches are required (yesterday’s technology will not necessarily be able to mine tomorrow’s deposits). Junior companies and service providers are particularly innovative when compared to majors, as they are more nimble, they have become adept at leveraging external partnerships for problem-solving, and they benefit most from government incentives. Mining supply and services companies play a key role in the diffusion of new technologies, particularly through the proving of pre-commercial technologies. Clean technologies, for example, often reach large mining companies after their installation and deployment by engineering, equipment, supply, and services companies. Many of these mining suppliers and service providers view themselves as key channels for the diffusion of clean technology in the sector, particularly given the industry’s widespread aversion to risk [10].

Strengthening the business case for innovation, the social and environmental benefits of innovation are also significant: increased safety on mine sites, fewer injuries, and less downtime, reduced environmental footprints, and greenhouse gas emissions, etc., are all resulting from the adoption of new technologies and techniques. All could further strengthen a company’s social license to operate [9].

These changes are happening within a broader context. The international community has embarked on the most ambitious global development agenda ever conceived, with the adoption of both the 2030 Agenda for Sustainable Development (which defines, through 17 goals and 169 targets), the global development agenda for the next 15 years, and the Paris Agreement on Climate Change. Achieving both ambitions (the Sustainable Development Goals -SDGs- and limiting global warming to 2°C), will require concerted efforts from countries, communities, civil society, and the private sector. The mining sector has an important role to play in both agendas[10].

For many resource-rich nations, the role of the mining sector in catalysing innovation and supporting the achievement of the development agenda is paramount. National governments around the world continue to emphasize innovation as a critical path not only to secure their economic goals but also to ensure social progress and environmental sustainability [11]. This is increasingly relevant, as global trends continue to put pressure on governments to become more forward-looking around critical issues such as globalization, climate change, population growth, emerging economies, environmental stewardship, inequality, and social benefits. Innovation can help nations become more competitive, environmentally responsible, and socially inclusive at a time of global economic uncertainties, increasing expectations on sustainable production, and growing sensitivities around local benefits and income disparity.
CONCLUSION

The minerals industry is facing a changing talent landscape. With digitalization and decarbonization necessitating new skillsets and with technology cycles that are getting shorter and shorter, the new panorama is transmitting pressure in the need of a trained workforce, and mining companies need to ensure that their boards and staff are properly constituted to support the transformations that the sector is currently undergoing, including fluency in such areas as technology integration, innovation, entrepreneurship, systems security, and cybersecurity.

Higher education has been evolving rapidly to respond to fast-changing demands. New technologies, sustainable solutions, and disruptive innovation are critical to achieving the objectives of the European Green Deal for 2050. To keep its competitive advantage and differentiation with the rest of the economies, the EU needs to increase significantly the large-scale deployment and demonstration of new technologies across sectors and the single market, building new innovative value chains. Being competitive requires the right conditions for entrepreneurs to turn their innovative ideas into actions and for companies of all sizes to thrive and grow.

A competitive industry depends on recruiting and retaining a qualified workforce. The combination of developing technical and soft skills is a challenge across the board. It is also essential to have a better balance between women and men in the industry. This includes encouraging women to study Science, Technology, Engineering and Mathematics, consider a career in technology, and invest in digital skills, thus improving the gender balance in creating and leading businesses.

The strategy to lead Europe’s industry towards playing a leading role in the ecological transition means reducing its carbon and material footprint and embedding circularity across the economy implicates the need to revolutionize the way things and products are designed, produced, used, and discarded. This more circular approach will ensure a cleaner and more competitive industry by reducing environmental impacts, alleviating competition for scarce resources, and reducing production costs. But this approach needs to start training now - years before they can reach their full potential- the engineers that will take ahead this transformation.

Similar programmes to MEITIM’s concept have not been found among other European universities or the reference universities studied in the rest of the world, a programme of MEITIM’s characteristics would have a very interesting potential market. The fact that it is developed by a consortium in which companies in the sector and research centres participate decisively, is a guarantee that the contents of the program will focus on those that currently demand the needs of the industry.

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REFERENCES


