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Shaping the future of mining; balancing responsible extraction of resources and related social impacts through the PRO SLO education initiative

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Abstract

The escalating global demand for minerals and metals, driven by rapid urbanisation and the transition to green and digital technologies, poses significant challenges for sustainable development. As the world population is projected to reach 9.7 billion by 2050, with nearly 70% residing in urban areas, the need for critical minerals such as lithium, cobalt, nickel, and rare earth elements is intensifying. These materials are essential for renewable energy technologies and electric vehicles, making them crucial for achieving global climate goals. However, the reliance on extractive activities, particularly in middle to low-income economies, exacerbates social and environmental issues, including livelihood disruptions, social conflicts, human rights violations, and occupational hazards.

In response to these challenges, the EIT-funded project 'Professional Social Licence to Operate (PRO SLO)' has been launched, bringing together experts from industry, research, and academia across Europe. The project aims to equip current and future leaders in the mining sector with the skills necessary to effectively manage Social Licence to Operate (SLO) processes. Through a comprehensive PhD Summer/Winter school programme, combining advanced teaching methods such as case studies, simulations, and workshops, PRO SLO addresses critical ethical, social, and environmental concerns. The initiative aligns with European Union policies on responsible mining, fostering sustainable practices to enhance ethical standards in the industry.

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1. Introduction

The rapid growth of the global population, coupled with accelerated urbanisation and the widespread deployment of green and digital technologies, is significantly increasing the demand for minerals and metals. According to the United Nations, the world population is projected to reach 9.7 billion by 2050, with nearly 70% of people living in urban areas [1]. This urbanisation trend is driving the need for infrastructure development, housing, and technological advancements, all of which are heavily reliant on a steady supply of various minerals and metals. The transition to a

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low-carbon economy further amplifies this demand. The International Energy Agency (IEA) has highlighted that achieving climate goals outlined in the Paris Agreement will require a dramatic increase in the processing of minerals such as lithium, cobalt, nickel, and rare earth elements, which are essential for renewable energy technologies and electric vehicles [2]. These elements are critical components in batteries, wind turbines, solar panels, and other technologies essential for sustainable development.

Moreover, the technological advancements in digital technologies, including smartphones, laptops, and other electronic devices, necessitate a constant supply of rare and precious metals like gold, silver, and platinum. As countries worldwide continue to digitise their economies, the demand for these metals is expected to surge. For instance, the global market for smartphones alone, which stood at over 1.5 billion units in 2020, is a significant driver of the demand for these critical metals [3]. However, the escalating demand for minerals and metals raises critical concerns regarding the sustainability of their supply. The limited availability of secondary resources, such as recycled materials, means that a substantial portion of this demand must be met through primary extraction. This situation places enormous pressure on mining operations to increase production, often leading to intensified environmental and social challenges.

Despite the critical role that minerals and metals play in fostering technological and economic progress, the reliance on extractive activities poses significant challenges, especially in middle to low-income economies where these activities are predominantly concentrated. While mining operations can drive economic growth and create employment opportunities, they often come with substantial social costs. Communities in sourcing countries frequently experience a range of adverse social impacts. These include livelihood disruptions, as traditional means of subsistence such as agriculture are often displaced by mining activities. Economic disparities can exacerbate social tensions, leading to conflicts and instability. Migration patterns may shift, placing additional strain on local resources and infrastructure. Moreover, human rights violations and corruption are prevalent issues in many mining regions, further complicating governance and community relations. Occupational safety hazards also remain a persistent concern, with mining being one of the most dangerous industries in terms of worker fatalities and injuries.

The adverse social impacts are often disproportionately borne by vulnerable groups, including indigenous populations, women, and children. For instance, mining activities can lead to the displacement of indigenous communities, stripping them of their ancestral lands and traditional livelihoods. Women in mining regions frequently face gender-based violence and discrimination, while children are at risk of child labour in informal mining operations [4]. Recent research by Poelzer [5] underscores these social challenges, emphasising the need for comprehensive strategies to address the societal dimensions of mining. The study highlights the multifaceted nature of social impacts, ranging from immediate health and safety concerns to long-term issues of social justice and equity.

In response to these multifaceted challenges, the European Institute of Innovation and Technology (EIT) Raw Materials funded project, 'Professional Social Licence to Operate (PRO SLO)', has been launched. This project aims to equip current and future leaders in the mining industry with the competencies needed to navigate the complexities of Social Licence to Operate (SLO) processes effectively. The concept of SLO is crucial in the mining sector, as it represents the ongoing acceptance and approval of mining operations by local communities and stakeholders.

By fostering a deeper understanding of the ethical, social, and environmental dimensions of mining, the PRO SLO project seeks to promote sustainable and responsible mining practices that can mitigate the adverse social impacts often associated with extractive activities. The project scope focuses on developing a Summer/Winter PhD school that employs advanced and innovative teaching methods. This educational initiative is designed to provide participants with in-depth knowledge and practical skills in managing SLO processes, addressing pressing ethical, social, and environmental concerns. The PRO SLO initiative aligns with European Union policies on responsible mining, supporting the promotion of sustainable practices and the advancement of ethical standards in the sector. By building a team of knowledgeable and ethically-minded industry leaders, the project aims to contribute to a mining industry that is not only economically viable but also socially responsible and environmentally sustainable.

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2. Educational strategies and policy frameworks

This section explores the interconnected domains of pedagogy, didactics, and policy. It offers insights into the methodologies and principles underlying effective teaching practices and outlines the strategies and techniques employed by PRO SLO in its development of the educational settings. By emphasising experiential learning, interdisciplinary collaboration, and the use of advanced digital tools, the section illustrates how these educational strategies foster a comprehensive learning environment. Additionally, it highlights the alignment with key EU policies, such as the European Education Area [6], the Digital Education Action Plan [7], and the Sustainable Development Goals [8], which govern and support these educational strategies. This alignment ensures that the PRO SLO initiative not only meets high educational standards but also contributes to broader societal goals.

2.1. Alignment with EU Education and Digital Acts

The PRO SLO initiative aligns with several key EU policies, including the European Education Area, the Digital Education Action Plan, and the EU's Sustainable Development Goals (SDGs):

The European Education Area (EEA) aims to create a unified space for education across Europe, where learning, studying, and research are unhindered by borders [6]. By 2025, the EU intends to ensure that students can easily spend time abroad for their studies, have their qualifications recognized across borders, and access high-quality education regardless of their socio-economic background. The PRO SLO initiative supports these goals by offering a collaborative, cross-border educational program that involves both academics and industry professionals from across Europe. This initiative fosters intercultural competencies and provides students with opportunities for international learning experiences.

The Digital Education Action Plan (2021-2027) seeks to enhance digital literacy and skills among EU citizens while promoting the effective use of digital technology in education [7]. The PRO SLO initiative integrates advanced digital tools such as virtual reality, simulations, and online collaborative platforms. These technologies create an immersive learning environment and encourage active engagement, aligning with the EU's vision of using digital technology to improve the quality and accessibility of education.

The EU is committed to the 2030 Agenda for Sustainable Development, which includes 17 Sustainable Development Goals (SDGs) [9]. The PRO SLO initiative directly contributes to several of these goals, particularly SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), and SDG 12 (Responsible Consumption and Production). By focusing on sustainable and ethical mining practices, the initiative promotes responsible resource management and economic growth that upholds social and environmental integrity.

The emphasis on ethical and sustainable mining practices aligns with the EU's commitment to responsible business conduct and environmental sustainability [10]. The PRO SLO initiative addresses critical ethical, social, and environmental concerns, contributing to the promotion of sustainable practices and the advancement of ethical standards in the mining sector. This alignment ensures that participants gain the knowledge and skills necessary to navigate complex social and environmental issues, fostering a more sustainable and responsible mining industry.

The alignment of the PRO SLO initiative with key EU policies such as the European Education Area, the Digital Education Action Plan, and the Sustainable Development Goals underscores its commitment to fostering a holistic and sustainable educational framework. By integrating advanced digital tools and promoting responsible mining practices, the initiative not only enhances the quality and accessibility of education but also ensures that participants are well-equipped to meet the ethical and environmental challenges of the mining industry. This comprehensive approach prepares participants to contribute effectively to a sustainable and inclusive future in line with EU priorities.

2.2. Pedagogical framework

The PRO SLO initiative is grounded in a strong pedagogical framework that emphasises experiential learning, interdisciplinary collaboration, and ethical decision-making. Drawing on the principles of student-centered learning, as advocated by educational experts such as Carl Rogers [9] and John Dewey [10], the initiative places the learner at

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the heart of the educational process. This approach ensures that the educational experiences are relevant, engaging, and tailored to the needs and interests of the participants.

The curriculum is designed using John Biggs' theory of Constructive Alignment [13], which ensures that learning outcomes, teaching methods, and assessment tasks are all aligned. This alignment creates a more effective learning environment where students understand the objectives of their learning and are assessed in ways that truly reflect their understanding and skills. Biggs' approach is critical in ensuring that the theoretical and practical components of the PRO SLO initiative are cohesively integrated, providing a seamless learning experience.

The initiative incorporates Carl Rogers' humanistic approach to education, which emphasises the importance of creating a supportive and non-judgmental learning environment [11]. This approach fosters self-directed learning, encouraging students to take ownership of their educational journey, promoting intrinsic motivation and personal growth.

John Dewey's principles of experiential learning are also central to the PRO SLO initiative. Dewey advocated for learning through experience and reflection, which is implemented in the program through hands-on projects, site visits, and real-world problem-solving activities [12]. This is further combined with challenge-based education, enhancing participants' understanding of theoretical concepts while also developing their practical skills and critical thinking abilities.

The curriculum also integrates Jean Piaget's theory of cognitive development, which emphasises the stages of learning that students go through as they build knowledge [14]. By tailoring educational content to the developmental stages of learners, the program ensures that complex concepts in SLO and mining ethics are introduced in a manner that is comprehensible and retainable for all participants.

Challenge-Based Education (CBE) is an innovative pedagogical approach that engages students in solving real-world problems, fostering critical thinking, creativity, and practical skills [15]. In CBE, students work on complex, interdisciplinary challenges developed by industry partners, adding relevance and immediacy to participants' learning experiences. Industry involvement in CBE is crucial, as it ensures that the challenges reflect current professional practices and emerging trends. Industry partners not only help in setting these challenges but also act as mentors, providing expert guidance, feedback, and real-world perspectives. This collaboration enhances the educational experience, bridges the gap between academic theory and practice, and better prepares participants to apply the competencies in their careers.

Learning outcomes of the PRO SLO school align with the overarching learning outcomes (OLOs) defined by the EIT handbook [11]. These include entrepreneurship skills, innovation skills, creativity, intercultural competencies, value judgements and sustainability competencies, and leadership skills. By the end of the programme, students are expected to understand the principles and business case for SLO, the dynamics of stakeholder networks, and the importance of social capital in establishing a legitimate SLO.

2.3. Didactics and Innovative Teaching Methods

The didactic approach of the PRO SLO initiative integrates both asynchronous and synchronous teaching and learning methods, utilising the insights of educational experts such as Salman Khan, who champions the flipped classroom model, and Clayton Christensen, a proponent of disruptive innovation in education. Asynchronous methods, including pre-recorded lectures, online discussion forums, and self-paced assignments, provide students with the flexibility to engage with the material at their own pace. This flexibility is particularly beneficial for accommodating diverse learning styles and schedules.

Flipped Classroom Model: Inspired by Salman Khan's flipped classroom model [12], students engage with lecture material online at their own pace before attending interactive, discussion-based classes, also held online. This model maximises classroom time for hands-on learning and personalised teacher support, fostering a deeper understanding of SLO processes.

Disruptive Innovation: Clayton Christensen's theory of disruptive innovation influences the programme's use of digital tools and platforms [13]. By incorporating virtual reality, simulations, and other innovative technologies, the programme provides an immersive and engaging learning experience that challenges traditional educational models and enhances student engagement.

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Synchronous methods, such as live webinars, interactive workshops, and real-time group projects, foster direct interaction and immediate feedback.

These sessions are designed to create a dynamic and collaborative learning environment, enhancing the sense of community and engagement among participants. The thematic areas covered include social issues related to sustainability and circular economy, stakeholder identification and partnership, the psychology of ethics, social and environmental conflicts, international SLO frameworks, crisis management, negotiations, and effective communication skills. These thematic areas are structured to foster critical thinking, problem-solving, and collaborative skills among participants.

2.4. Assessment framework

The PRO SLO initiative will utilise Challenge-Based Education (CBE) as a comprehensive framework for assessing participants' competence in achieving the defined learning outcomes (LOs). CBE engages participants in solving real-world problems that are directly relevant to the field of the PhD school, fostering critical thinking, creativity, and practical skills. By integrating CBE into the assessment strategy, it ensures that the evaluation of participant performance is both comprehensive and reflective of real-world professional demands.

Real-world relevance and industry collaboration: In CBE, challenges will be designed in collaboration with industry partners to ensure that the problems posed are current and relevant. Industry professionals will set the cases and act as mentors throughout the learning process. By working on these industry-driven challenges, participants will gain practical insights and experience, bridging the gap between academic knowledge and professional practice.

The assessment of participants' competence through Challenge-Based Education (CBE) will involve multiple dimensions:

Process evaluation will focus on participants' ability to accurately define and understand the problem by identifying key issues, stakeholders, and constraints. This will involve the submission of a detailed problem statement, which will be evaluated using a rubric to ensure clarity, thoroughness, and relevance.

Solution development will assess the creativity and feasibility of the solutions proposed by participants through written proposals and presentations. Participants must outline their methods for developing solutions and justify their choices based on potential impacts. These proposals will be scored based on innovation, practicality, and alignment with the identified problem.

Implementation and testing will evaluate participants' skills in implementing their solutions by observing their execution in controlled environments or real-world settings. Participants will document their process, conduct tests, and iterate based on feedback. Assessors will evaluate technical abilities, problem-solving skills, and responsiveness to feedback through direct observation and process logs.

Outcome evaluation will include the quality of solutions, where effectiveness, innovation, and practicality will be key metrics. Solutions will be reviewed for their theoretical soundness and practical applicability using detailed scoring rubrics. Participants will present their solutions to a panel of experts for evaluation. Additionally, impact assessment will evaluate participants' ability to assess the potential impact of their solutions on various stakeholders and the environment. This will involve preparing impact assessment reports that analyse both immediate and long-term consequences, with assessors reviewing these reports for thoroughness and accuracy.

Finally, reflection and communication will involve participants maintaining reflective journals that document their learning process, challenges faced, and strategies used to overcome them. These reflections will be evaluated for depth of understanding, self-awareness, and critical thinking. The ability to effectively communicate findings, both in written and oral forms, will also be assessed, including clarity of presentation, persuasiveness of arguments, and proficiency in addressing diverse audiences. Assessors will score the quality of communication using standardized criteria.

Mentorship: Industry professionals involved in setting the challenges will also participate in the assessment process. Their role as mentors will provide participants with continuous feedback, guiding them through the iterative process of problem-solving. This mentorship will not only enrich the learning experience but also ensure that the

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assessment is aligned with industry standards and expectations.

Continuous Improvement: The CBE framework allows for continuous improvement of both the learning and assessment processes, by integrating these methods, the assessment will comprehensively evaluate participants' competencies across all dimensions, ensuring a thorough and fair evaluation method. Feedback from industry mentors, peer reviews, and self-assessments will be used to refine the challenges and enhance the overall educational approach. This iterative process will ensure that the PRO SLO initiative remains responsive to the evolving needs of the mining industry and its stakeholders.

By using CBE to assess participants' competence in achieving the LOs, the PRO SLO initiative ensures that participants are not only knowledgeable but also capable of applying their skills in real-world contexts. This approach prepares participants to meet the complex demands of their future careers in a responsible and sustainable manner.

3. Conclusion

The PRO SLO initiative stands at the forefront of integrating cutting-edge educational methods with practical industry challenges, tailored, but not exclusively, for the mining sector. Launched in October 2023, and funded by EIT Raw Materials, this three-year project is set to enhance current mining education and foster sustainable practices. Addressing the rising global demand for minerals and metals due to population growth, urbanisation, and the transition to green and digital technologies, the initiative emphasises the need for responsible and ethical mining by navigating the complexities of a social licence to operate. It seeks to mitigate the adverse social impacts associated with mining by blending theoretical knowledge with hands-on, experiential learning.

The PRO SLO curriculum is meticulously designed to align teaching methods and assessment tasks with clearly defined learning outcomes. This ensures a cohesive learning experience where students develop a comprehensive understanding of sustainable development, ethical principles, and lifecycle management in the raw materials industry. The programme incorporates both asynchronous and synchronous learning methods, offering flexibility and accommodating diverse learning styles. Key to this initiative is Challenge-Based Education (CBE), where participants tackle real-world problems presented by industry partners. This approach not only enhances learning relevance but also bridges the gap between academic concepts and practical application. Industry professionals play a crucial role in mentoring students, providing expert guidance and feedback, thus enriching the educational experience and ensuring alignment with current professional standards.

The first PhD school will commence its online segment in January 2025, followed by an immersive on-site experience. As part of the project's commitment to maintaining high educational standards, an application for the EIT label for non-degree education is underway. This label, once granted, will certify the quality of the PhD school and provide recognised validation of its educational content and impact. Aligning with major EU policies, including the European Education Area, the Digital Education Action Plan, and the Sustainable Development Goals, the PRO SLO initiative supports the EU's vision of an inclusive and innovative educational ecosystem. The programme leverages advanced digital tools and promotes sustainable mining practices, contributing to broader societal goals of sustainability, inclusion, and innovation.

In essence, the PRO SLO initiative is poised to develop a new generation of industry leaders equipped with the skills, knowledge, and ethical grounding needed to navigate and lead in a rapidly evolving world. This comprehensive educational approach not only addresses the immediate needs of participants but also contributes to a sustainable and inclusive future, in harmony with EU priorities. Through the synergy of academia, industry, and policy, PRO SLO is set to make a lasting impact on education and practice.

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