



## EXPERIENCES OF MINING ENGINEERING STUDENTS IN COOPERATION FOR DEVELOPMENT

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**ABSTRACT**

Future engineers, in addition to technical knowledge, should incorporate in their academic curricula aspects that contribute to make mining a sustainable activity. This will contribute to changing the concept that society has about mining and to be a socially accepted activity. In the mining engineering studies at the Universitat Politècnica de Catalunya (UPC), students have the opportunity to develop cooperation projects together with professors and other staff members. They all collaborate with artisanal miners from different underdeveloped countries, mainly from Latin America, and contribute to making mining more environmentally friendly. Moreover, they have the opportunity to acquire a social sensitivity that can be of great importance during the development of their professional career. This study presents some experiences of undergraduate, master, and doctoral students in cooperation activities in mining. The projects were developed as a collaboration between UPC and universities or NOGs in Latin America. The activities have been carried out in underdeveloped areas where mining is practiced with a high environmental impact and poor use of resources. A survey among the participants in the projects shows the students' favourable perception of this activity.



## 1 INTRODUCTION

The supply of mineral raw materials is essential for the well-being and growth of the economy and society. Thus, today's high technological development is accompanied by an increasing need for, and dependence on, a large number of metals. Currently, 30% of the metals that we use are recycled; the other 70% must come from mines. So, it is clear that we have to mine, but we have to do it sustainably.

In mining schools, there is an emerging awareness of the responsibility to train engineers with values that ensure that sustainability is always present in their activities. Future mining engineers must reconcile the requirements of the economy, the environment, and society. Therefore, the inclusion of sustainability in education represents a great opportunity to train engineers with a sense of responsibility for the future. In order to obtain raw materials in an optimal way and with a minimum impact on the environment and in a safety work conditions, the different activities involved must be carried out based on in-depth scientific and technological knowledge.

At the Universitat Politècnica de Catalunya (UPC) students are trained to be future professionals in mining engineering. In this case, in addition to acquiring scientific and technological knowledge, the training also includes the acquisition of social values, which will be of great importance in the future development of their profession. To this end, every year we carry out cooperation projects in mining areas from developing regions, where mining is still a long way from being sustainable. The Centre de Cooperació per al Desenvolupament (CCD) is a UPC body that every year launches calls for cooperation projects in which students, lecturers, and staff of the university can participate and carry out work to cooperate with institutions in developing countries and thus contribute to their development. It is based on the premise that the University has the responsibility to be actively involved in the promotion of solidarity and equity among people and the promotion of better human and sustainable development in the world, supported on its activities of teaching, research, and the transfer of knowledge and technology. In this regard, the UPC incorporated sustainability skills into the curricula [1].

This work presents the cooperation projects carried out through the Mining Engineering section of the UPC between 2012 and 2021. In this period 20 projects were developed in the Mining Engineering section and about 40 students were involved in these cooperation activities. They moved to the study areas where they carried out the planned cooperation activities. Projects aimed at improving tin mining in Bolivia and gold mining in Peru and Bolivia are presented as case studies.

The projects involve participants from Spain and the beneficiary countries. Part of the development of the projects is carried out in the mining areas of the developing countries, where the students, together with their professors, carry out the assessment of the mining activities and a sampling for the development of the research. In addition, here they have the opportunity to work alongside with miners, local university professors and the population of these communities. Once back in Catalonia, the research associated with the project is carried out at the university. Often, this



research is part of the degree, master's or doctoral thesis of the students participating in the projects.

## 2 BACKGROUND

A sustainable mining operation must be safe, economically profitable, efficient in the use of mineral resources, and environmentally clean [2]. To achieve these targets, it must combine the extensive scientific and technological knowledge with care for the environment and the health of workers. In contrast, artisanal mining is carried out by cooperatives, and even by the individuals, with limited scientific and technological knowledge, which does not allow it to be done efficiently [3]. The exploitation of resources under these conditions entails physical, biological, social, and economic issues. Examples in Peru and Bolivia highlight the generation of acid drainage, mercury pollution, high levels of occupational hazards, and low recovery during the processing of the ores. Rational and optimised exploitation of deposit is only possible if their geology, mineralogy, and type of deposit are known. On the other hand, ore chemistry and liberation characteristics allow the selection of the most effective processing methods to maximise the recovery efficiency and prevent environmental pollution.

Artisanal mining significantly contributes to the economy of developing countries and provides work for many of its inhabitants, creating employment opportunities and reducing poverty [4,5]. There is, therefore, a need to improve the conditions under which artisanal mining takes place. For artisanal mining to be sustainable, miners need to be empowered through carefully designed training programs [6,4] and to share with them the most appropriate processing techniques and how to carry them out. However, it is also necessary to know the detailed mineralogy of the ores and gangue at the mining sites.

On the other hand, one aspect that should never be overlooked is the pollution caused by mining activity. Several institutions and non-governmental associations explain to miners how the pollution produced during their mining activity affects to the environment and to the human health. However, this information does not encourage them to make changes in their methods. Miners will consider changing their practices if they perceive that this will increase their economic benefits [6].

## 3 METHODOLOGY

In order to assess the impact of the cooperation projects on the students, a survey among some of the participants was carried out. It is also relevant to present their views in a time perspective, allowing them to better assess the influence of these experiences on their subsequent activities. Seven survey questions are presented here:

1. Do you think that Development Cooperation projects are a good and enriching professional complement for students?



2. Do you think that Development Cooperation projects are a good complement on a personal level?
3. Do you think that the projects in which you participated provided solutions (total or partial) to the problems they addressed?
- 4 Do you think that the experience in Development Cooperation projects will influence possible future career decisions?
- 5 Would you like to repeat the experience of Development Cooperation projects?
- 6 How many of the 17 SDGs (2020-2030) have been positively influenced by the Development cooperation projects you have participated in?
- 7 Summary in a few words the experience of the Development Cooperation projects

## **4 RESULTS**

### **4.1 Case studies**

#### **4.1.1 Gold mineralisation and processing in Bolivia and Peru**

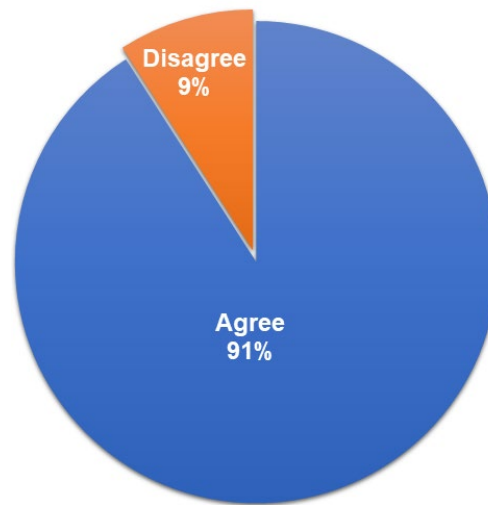
The collaboration with artisanal mining was carried out in the Arequipa department of Peru and in the La Paz department of Bolivia. Local mining is mainly underground, done through galleries excavation, except in the Mapiri area, from Bolivia, which is of alluvial type. In both cases, miners use mercury as gold recovery method. The studies were focused to determine the main characteristics of the deposits, as the tectonic structures, mapping of the orebodies, gold grade and mineralogy and chemistry of gold and associated minerals, in order to propose the most appropriate processing technique. Studies were also carried out on mining safety and environmental pollution. The influence on the health of the miners and their families was assessed by analysing the mercury content in their hair. These results have been presented to the miners along with proposals to reduce the use of mercury in the short and long term. They were very concerned about the results presented and, at least in some cases, some measures to reduce mercury exposure were implemented.

#### **4.1.2 Tin and indium mineralisation**

Tin production is the main economic input of Bolivia. Collaboration with several cooperatives was carried out for the study of the geology of the deposits, the detailed mineralogy to increase efficiency in the processing plants, and the environmental pollution produced by the mining activities. As a result, the miners were provided with a detailed knowledge of the geology and mineralogy of several mines. This made it possible to establish the metals of interest in each case and their characteristics for recovery. Thus, for example, it was shown that tin is found in some mines in significant quantities in the form of the stannite mineral. However, in the Bolivian processing plants usually, only cassiterite is recovered, and stannite is removed into the tailings. Another important result was the determination of significant amounts of indium and rare earths, which are critical metals, in many of the deposits. The importance of this finding is strategic, not only for Bolivia but also worldwide.

## 4.2 Students valorisation of the projects

The responses of the seven questions are presented in Figures 1 and 2. The first five questions were set as double choice answers. All the students agree that Development Cooperation projects are a good and enriching professional complement for students and that participation in projects of Cooperation for Development is a good complement on a personal level. Most of the respondents (90%) agree that the projects in which they participated provided total or partial solutions to the problems they addressed (Figure 1). All of them agree that their experience in Development Cooperation projects will influence possible future career decisions. The total of respondents would repeat the experience of Development Cooperation projects.



*Fig. 1. Responses to the question of the projects of Cooperation for Development are a good complement on a personal level.*

Question 6 aims to observe how the participants perceive the influence of the cooperation projects they have carried out on the achievement of the 2030 Sustainable Development Goals (SDG). All respondents consider that the projects they have been involved in have contributed to achieving some of the SDGs 2020-2030. Mainly SDG 8 "Decent work and economic growth", but also SDGs 3 "Good health and well-being", 6 "Clean water and sanitation" and 13 "Climate action" (Figure 2).

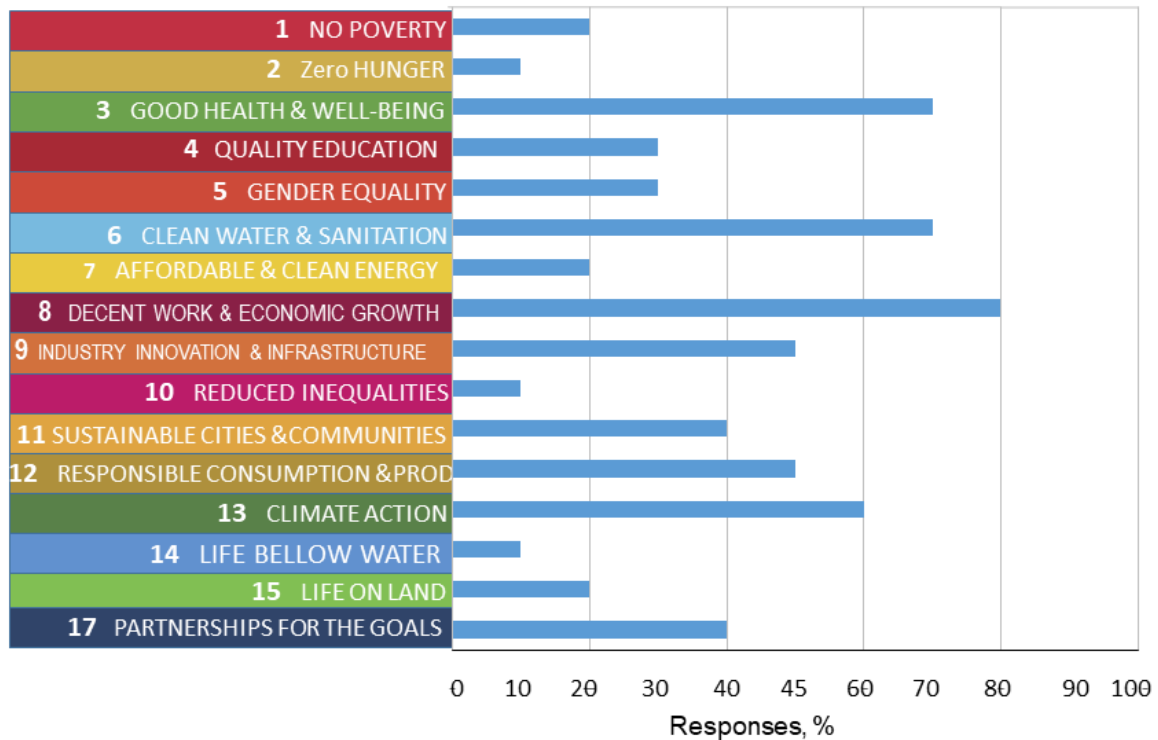


Fig. 2. Impact on the SDGs 2030 of the cooperation projects carried out according to the participants surveyed.

In reference to the experience of Development Cooperation projects students emphasised that the projects gave them considerable experience, both on a personal level as well as professional. In addition, they expressed that the first hand contact made them empathise with the communities in developing countries.

Respondents believe that it was a really good experience to have the opportunity to apply the concepts learned in classroom to real cases. They point out that having the opportunity to share knowledge with colleagues and experience the limitations of some projects and see how to deal with them made development cooperation projects an amazing experience. Therefore, they consider that it was an experience that helped them to improve as professionals. All the respondents agreed that it was an unforgettable, enriching experience that they would like to repeat.

#### 4.3 Overall assessment of projects

The implementation of the cooperation projects has had a positive impact on both the students and the beneficiaries of the cooperation. On the one hand, the surveys show that the students have acquired a high degree of social sensitivity, an aspect which will be fundamental in the development of their profession. In this context, sustainability criteria are increasingly being applied.

On the other hand, the research carried out has given the miners a better understanding of the characteristics of their mining activities and how they can improve



them in order to achieve better yields and less environmental and occupational health and safety impacts.

Local researchers have also been trained, so that universities in developing countries have the skills to conduct research that directly affects the people around them.

## 5 SUMMARY AND ACKNOWLEDGMENTS

Development cooperation projects have been mainly undertaken in Peru and Bolivia. These projects have made students more aware of the problems caused by mining around the world. It is well known that mining actions interact directly with the environment by extracting non-renewable resources. Therefore, future mining professionals must be aware of the importance of building environmentally friendly mining activities. To conclude, it is believed that sustainable mining activities can lead to the development of more sustainable and fair communities.

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