APPLICATION OF A NEW METHODOLOGY FOR RESEARCH AND IMPLEMENTATION OF TECHNICAL PROJECTS IN DEVELOPING COUNTRIES FOLLOWING SUSTAINABLE DEVELOPMENT GOALS AND CHANGING INTO A CIRCULAR ECONOMY

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Abstract

Teaching in higher education institutions about the development of technical projects can no longer follow the same principles that were followed a decade ago. Nowadays, new criteria must be included in the development process and even the methodology for dealing with them must be modified. For this reason, a change in the academic curriculum in technical degrees, especially when related to natural resources projects, is not only necessary but also urgent.

The inclusion of concepts such as the Sustainable Development Goals (SDGs), the circular economy, social integration, and energy self-sufficiency, among others, in the training phase of future engineers is essential for the development of new real industrial projects, and even more so in the case of countries with scarce resources.

This paper discusses the design of a new methodology within the process of advancement and development of a project for the use of raw materials, intending to modify the teaching methods used in technical careers such as engineering. This will allow those future professionals who will have to effectively develop those new projects, acquire the necessary skills. But together with acquiring those skills, it is important they fully internalize during their training phase the importance of addressing in parallel a decision-making process that is not only based on economic criteria but also those mentioned above.

The real case selected for the creation of the new methodology is a project for the recovery of mineral resources in the Republic of Cuba. In it, the objectives and goals of sustainable development are classified according to their direct or indirect involvement, indicating at each step how it affects the decision-making and developing a new educational proposal for university training in technical careers.

Keywords: Sustainable Development Goals (SDGs), circular economy, education methodology, projects, Cuba.

1 INTRODUCTION

Higher education is the last stage of the academic learning process. It comprises the education provided after high school or its equivalent, and the functions of the institutions (universities, colleges, or technical training academies) are to train human resources in the various fields of science, technology, and the humanities.

Higher education in technical profiles has developed over more than 200 years. Each era introduced new concepts and/or ways of carrying out projects into the curricula so that future graduates could be involved in the latest techniques. In recent decades, the trend has been to incorporate in the training of students, the fact that in projects there are factors not directly related to the environment, the regional economy in the areas where operations or projects are developed, and above all in the social impact, and that they have an important impact on the development of projects in one way or another.

In the 1990s, it was the automobile industry that began to introduce indicators on the pollution emitted by its vehicles, trying to reduce them with each new model. At the same time, in other areas, they began to think about how to integrate social improvements that would allow manufacturing in developing countries, where labour was cheap but unskilled, and to gradually introduce new models in which the company would provide adequate training to qualify its employees and develop products that were as competitive as those manufactured in developed countries.
All these improvement indicators were integrated into new terms that quickly became popular, such as sustainability, which included three main pillars: economic, social, and environmental, as well as governance.

On 25 September 2015, world leaders adopted a set of 17 goals and 169 targets, called Sustainable Development Goals (SDGs), with an integrated and indivisible character, global impact, and universal application, to be achieved in the next 15 years, to eradicate poverty, protect the planet and ensure prosperity for all as part of a new sustainable development agenda. It should be noted that the implementation of these goals is not legally binding, however, countries are expected to adopt them and establish national frameworks for their fulfillment, while their achievement and success should be based on national sustainable development policies, plans, and programmes, and each government should be responsible for monitoring and reviewing progress [1]. Figure 1 shows the list and subject matter of each.

All of the above leads to highlighting the importance of training and higher education as a means to undertake the necessary changes at all times by professionals in each sector more quickly. In this work, it is proposed that, during the teaching of methodologies to carry out industrial projects, a new one is established that not only includes economic aspects such as costs or execution time but also takes into account these sustainable development objectives, from the moment of decision-making in each step or milestone of the project, and not later trying to adjust them to a project already in execution.

To show a good example of the proposed new methodology to be implemented in teaching, an industrial sector and a type of project must be selected on which to explain step by step how to arrive at the proposal of actions that are integrated into the decision-making process. Decisions at the preliminary project level and that are easy to implement when moving from the project stage to the actual execution of the project. This is because otherwise, it would only be a declaration of good intentions that ultimately would not achieve the desired effect, the achievement of goals.

In this case, the proposed methodology, explained below, is applied to an exploration project for mineral raw materials in Holguín (Republic of Cuba), which includes the use of resources, not used in the first instance, to the development of other products, such as construction materials usable in the region and comply with the principles of the circular economy.

Since ancient times, mining-metallurgical activities or the extraction of mineral raw materials have served to develop economic activities and satisfy the needs of human societies [2]. Current technologies allow the use of mineral resources of much lower quality, but this implies a greater generation of waste, which translates into greater pressure from authorities and environmental groups. It is increasingly difficult to start the exploitation of a “greenfield” mining project (newly discovered), and the vast majority of current mining projects correspond to expansions of “brownfields” (areas explored and even exploited in the past), practically being It is mandatory for mining companies to integrate sustainability tools into their management that measure their degree of compliance [3].
2 METHODOLOGY

The methodology that is proposed to be included within the training of students so that they can later apply it to an industrial sector and a specific type of project when they work, is based on completing three steps that will show, as a conclusion, a final proposal of a series of concrete actions that comply with the principles set by the goals and objectives of sustainable development. These should be raised at the right moment in which it is decided to carry out a preliminary pre-feasibility study to present the agents that will finance the actual execution of the project.

The first step can be summarized in four phases [8], including the actions that lead to completing each one:

1. Understand what the SDGs are and their purpose.
   a. Explore the UN 2030 Agenda for Sustainable Development.
   b. Understand the vision adopted by the UN 2030 Agenda.
   c. Consider the process followed in the design and adoption of the SDGs.
   d. Discuss the spirit of the objectives.
   e. Reflect on the different stakeholders.

2. Understand the requirements for its achievement.
   a. Understand the shared principles and commitments that underpin the UN 2030 Agenda.
   b. Consider application and reporting approaches, with their associated complexities.
   c. Reflect on the need for collaboration to achieve the objectives.

3. Explore the goals and detailed metrics or indicators of the SDGs.
   a. Understand the rationale behind each objective.
   b. Know what each objective aims to achieve.
   c. Consider the types of goals applied within and between goals.
   d. Determine if the objectives are explicit and if they are not.
   e. Consider the different metrics linked to the different goals.

4. Establish a relationship between the SDGs and the business sector to which the project and the company belong.
   a. Review industry perspectives on the SDGs, in your business sector and elsewhere.
   b. Consider how industry sectors have connected their approach to the SDGs.
   c. Understand in which cases compliance with the SDGs requires impact management.
   d. Explore where the SDGs identify or create opportunities.
   e. Explore best practice approaches.

The case study selected to apply this new methodology would be a project for the extraction of raw materials in the province of Holguín, in the Republic of Cuba. To establish the parameters or indicators that can be measured directly or assimilated later in the second step of the methodology, the “White Paper: Mining Cartography concerning the Sustainable Development Goals” [10], prepared in 2016 by different professionals dedicated to the mining-metallurgical activity, mining relations and the SDGs, which lays the foundations for the generation of a sustainable mining management system.

A first analysis of the SDGs that have a direct and indirect relationship in the activities of the project for the valuation and extraction of raw materials is established. In figure 2, an image of the classification performed is shown.
A mapping is made between the SDG theme and the challenges and opportunities of the project in question. To do so, we must answer a series of questions that depend on each project, sector, and geographical location, among others. The following can be highlighted:

1. What are the most important sustainable development challenges that the project faces?
2. What are the most important sustainable development opportunities?
3. How do these challenges and opportunities relate to the challenges and opportunities facing the world?

The result of the analysis will not have a single solution but the most common options are:

- Worker safety (Goals 3 and 8)
- Employee and community health issues (Goals 3, 8, and 10)
- Contribute to the self-sufficiency of communities (Goals 1, 2, 8, 10, 11, and 16).
- Responsible environmental management (Goals 6, 7, 12, 13, and 15)
- Integrated mine closure planning (Goals number 11, 12, 13, and 15)
- Employee, community, and asset security (Goals 3 and 16)
- Respecting human rights (Goals 10 and 16)
- Artisanal and small-scale mining (legal and illegal) (Goals 1, 3, 5, 8, 10, 16)
- Talent management, competence development, and employee relations (Goals 4, 5, 8, and 10)
- Navigating regulatory and political uncertainty and risks (Goal 16)

As an application example, the analysis of sustainable development goal 1: The end of poverty is shown below, using tables 1 and 2.

<table>
<thead>
<tr>
<th>GOALS</th>
<th>TARGETS</th>
<th>INDICATORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: NO POVERTY</td>
<td>1.1 Eradicate extreme poverty.</td>
<td>1.1.1 Proportion of the population living below the international poverty line, disaggregated by sex, age, employment status, and geographical location (urban/rural)</td>
</tr>
<tr>
<td></td>
<td>1.2 Reduction of relative poverty in all its dimensions.</td>
<td>1.2.1 Proportion of the population living below the national poverty line, broken down by sex and age</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2.2 Proportion of men, women, and children of all ages living in poverty in all its dimensions, according to national definitions</td>
</tr>
</tbody>
</table>
1.3 Implementation of social protection systems.

1.3.1 Proportion of the population covered by social protection floors or schemes, disaggregated by sex, distinguishing between children, unemployed, elderly, persons with disabilities, pregnant women, new-borns, victims of occupational accidents, and the poor and vulnerable groups

1.4 Ensuring Access to Basic Services and Financial Resources

1.4.1 Share of population living in households with access to basic services

1.4.2 Proportion of the total adult population with secure land tenure rights: (a) who have legally recognised land tenure documentation and (b) who consider their rights secure, disaggregated by sex and tenure type

1.5 Resilience to environmental, economic, and social disasters.

1.5.1 Number of people killed, missing, and directly affected attributed to disasters per 100,000 inhabitants

1.5.2 Economic losses directly caused by disasters concerning world Gross Domestic Product (GDP)

1.5.3 Number of countries with disaster risk reduction strategies at national and local levels

1.5.4 Proportion of local governments adopting and implementing local disaster risk reduction strategies in line with national disaster risk reduction strategies

1.A Build resilience to environmental, economic, and social disasters.

1.a.1 Proportion of domestically generated resources that are directly allocated by the government to poverty reduction programmes

1.B Creating policy frameworks to eradicate poverty.

1.b.1 Pro-poor public social spending

<table>
<thead>
<tr>
<th>ACTION</th>
<th>ASPECT TO ASSESS</th>
<th>PARAMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promoting inclusive employment 1.1,1.2,1.3 and 1.4</td>
<td>Promoting equitable access to employment opportunities for people in zone 1.1,1.2,1.3 and 1.4</td>
<td>Percentage of local employees out of total employees.</td>
</tr>
<tr>
<td></td>
<td>Delivery of training and apprenticeship programmes 1.1,1.2,1.3 and 1.4</td>
<td>Have a programme or initiative that encourages the hiring of local labour.</td>
</tr>
<tr>
<td></td>
<td>Capacity building of local suppliers 1.5.1.A</td>
<td>Number of local suppliers providing services or supplies out of total suppliers</td>
</tr>
<tr>
<td></td>
<td>Strengthening local value chains 1.5.1.A</td>
<td>Participate in a programme or initiative that encourages you to train local suppliers for your company's needs.</td>
</tr>
<tr>
<td>Preservation of access to land 1.B</td>
<td>Considerations on access to land by the population in early stages of planning 1.B</td>
<td>Binding instances are generated permanently, where stakeholders can raise their concerns regarding the mining project.</td>
</tr>
<tr>
<td></td>
<td>If applicable: Guarantees for resettlement and subsequent land reclamation. 1.B</td>
<td>It has a binding agreement that provides guarantees of access to basic services and subsequent land reclamation.</td>
</tr>
<tr>
<td>Payment of taxes or royalties 1.B</td>
<td>Detailed publication of payments made to governments and making them public. 1.B</td>
<td>Annual sales are reported and along with this, the amount of the respective taxes payable to the local authorities. 1.B</td>
</tr>
</tbody>
</table>

Table 2. Actions to be developed achieve the targets of SDG 1: No poverty.

To finish illustrating the first step, the connection between, for example, the second action and the exact goal it relates to in the context of the aforementioned project are explained below.

Due to its geographical location, the Republic of Cuba is subject to natural disasters such as earthquakes and more commonly hurricanes or tropical storms. The action to promote local procurement mechanisms through the development of local suppliers and the reinforcement of the local value chain...
due to the exploitation of a project, in this case of raw materials, allows that in the face of a natural disaster that affects the area, the supply of essential goods is guaranteed, not having a long waiting time due to the need to import these goods from other more distant places, with the consequent negative impact on health and the local economy. This action improves resilience to disasters (Target 1.5) and even encourages it (Target 1.A).

When investing in a local industrial project, in this case, an exploitation of natural resources, and hiring local labor, the first positive impact it generates is the development of local suppliers, from secondary industries that serve the project to the development of the service sector with supermarkets, restaurants, accommodation, health infrastructures, and even leisure. These play a very important role in natural disasters since they guarantee basic goods in the first hours and days after a disaster and avoid the interruption of supply until they can access external help from their national government or even from other supportive countries.

The second step consists of identifying the general actions proposed in the first step for projects of the same type and industrial sector to which the methodology is to be applied and including it in the procedure of the works and decisions to be detailed in the pre-project. Continuing with the example chosen in this work, only some proposals are shown on how to implement it in the research phase of the raw materials project.

The research phase of a mineral deposit is a set of technical and management processes and activities that lead to the discovery, definition, and technical and economic evaluation of a deposit [13]. This phase includes:

- Opportunity study or concept study
- Selection of areas
- Site area reconnaissance
- Exploration of targets
- Resource assessment

For the first two phases, it is hardly necessary to go to the area or location, so the impact is zero. Once it is decided to start the reconnaissance, the tasks would include flights to take aerial photos, and as we progress in the exploration, tests, or sampling. In these stages, local companies can and should be chosen, take into account nearby population centers, such as Holguín and to carry out surveys or pits of the land, subcontract local companies and operators as far as possible, encouraging training courses for future workers who wish to be hired in the project. With this example, it is shown how it is possible to gradually integrate into the development of the project actions that bring even closer to meeting the proposed goals and influence the global indicators that measure the level of compliance with the SDGs. If in the research phase the possible waste is identified and characterized, it is possible to find some other use that consumes it, thus avoiding a problem before it appears and complying with the bases of the circular economy.

The third and final step is to select a tool that evaluates the type of activities to be developed and is capable of assessing sustainable development in this case of the company undertaking or managing the project. To do this, a study is made of the main existing evaluation systems in terms of sustainability and, if possible, employing a version specialised in the sector's subject matter, as this will imply already established indicators that allow for quantification or comparison and do not require the creation of these beforehand.

The importance that the impacts generated or that may be generated due to the installation of new industrial activity in certain latitudes have taken on, in all industrial areas without exception, has led to the creation of tools and indices that, in some way, attempt to evaluate the actions and decisions taken or to be taken by a company. The current tools, for the most part, have focused on environmental impacts, carrying out life cycle analyses (LCA), but these requirements have increased not only on the part of the authorities but also on the part of society, which over the years has come to be known as the "social license".

The most commonly used general models for measuring the sustainability of a company and its projects are the PSR (Pressure-State-Response) and the DPSIR (Driver-Pressure-State-Impact-Response) which complements the internal one by introducing impact indicators.

Possibly the most complete generic tool for evaluating companies and their behavior in projects is the Down Jones Sustainability Index (DJSI). It measures the three edges of what has been defined as
sustainable development, that is, on the one hand, it measures the environmental impact and, on the other, the economic performance and finally the social impact. The problem it presents is that its application conditions are too restrictive since it does not evaluate companies that are not listed on the stock exchange and are among the 10% of the best in their sector, making application and examples difficult for smaller-scale companies and projects.

### Table 3. DJSI weighting criteria for the assessment of companies. [20]

<table>
<thead>
<tr>
<th>SUSTAINABILITY PILLAR</th>
<th>ISSUE</th>
<th>ASSESSMENT</th>
<th>OVERALL WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic</td>
<td>Corporate structure</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Materiality</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Risk and crisis management</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Codes of business and conduct</td>
<td>8%</td>
<td>33%</td>
</tr>
<tr>
<td></td>
<td>Political influence</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supply chain management</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tax strategy</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>Environmental</td>
<td>Environmental reports</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Environmental policies and systems management</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operational eco-efficiency</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biodiversity</td>
<td>3%</td>
<td>32%</td>
</tr>
<tr>
<td></td>
<td>Climate strategy</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tailings management</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water-related risks</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Social</td>
<td>Social reporting</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Work practice indicators</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Human rights</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Human capital development</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Talent attraction and retention</td>
<td>2%</td>
<td>35%</td>
</tr>
<tr>
<td></td>
<td>Philanthropy and corporate citizenship</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Occupational Health &amp; Safety</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mine closure management</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social impacts in communities</td>
<td>8%</td>
<td></td>
</tr>
</tbody>
</table>

In the comparative study of tools or sustainability indices, the Standard & Poor family of indices has also been studied in collaboration with RobecoSAM, which is aimed at promoting companies concerned with reducing their carbon footprint and fuel consumption. Another family of indices, created by the company FTSE Russel, is the “FTSE4Good Index Series”, which are designed to measure the “performance” or performance of companies that demonstrate solidity in their management and interaction with the environment and the social environment. And that, like the DJSI, are listed on the stock market.

Lastly, the standardization for monitoring sustainability has been studied for this specific work on educational innovation with application to future professionals in the extractive industry. The best and closest example is the recently updated Spanish standard UNE 22470 [5,6], which specifies the requirements for the development of a sustainable management system regardless of the activity related to mining carried out by the project or the company. In it, the organization is responsible for its implementation, monitoring, and improvement of the system since it is not required to apply unless accredited is desired. It details the need for exhaustive planning to:

a) Address risks and opportunities
b) Plan to achieve stated objectives; and
c) Plan for changes if they are.
Regarding the part of indicators, they can be summarized in seven main criteria that are:

1. Security of supply,
2. Efficient use of resources,
3. Implementation of measures to improve the safety and health of workers,
4. Contribution to the economic development of the community,
5. Contribution to the social development of the community,
6. Rehabilitation of the affected natural area, and
7. Application of the best pollution control and waste management techniques.

Regardless of the internal measurement of the global sustainability situation of each project and company, the best way to communicate it and that it can be measured and compared is to publish it through a report with a more or less fixed structure over time. The report most used today is the GRI project (Global Reporting Initiative) [7] which proposes standards that are specified in three universal guides and three specific guides, in addition, it has a specific guide for each industrial and commercial sector. In the case of the mining-metallurgical industry, it was created in 2005, in conjunction with the International Council of Mining and Metals (ICMM), which is complemented by the guide for the preparation of sustainability reports, launched in 2002.

3 RESULTS

The proposed methodology offers a method of easy integration in the subjects taught in higher education centers concerning the performance of a project that enforces or, at least allows to improve, sustainability before, during, and after its execution.

In addition, by selecting the appropriate tool(s), students and future professionals will be able to assess, at all times and both internally and externally, through audits, the development of the entire process. The integration of this methodology in the teaching phase accelerates the availability for companies of technical personnel who know how to implement actions in favor of sustainability and the circular economy in the performance of a project.

The Education for Sustainable Development (ESD) not only integrates content such as climate change, poverty, and sustainable consumption into curricula but also creates interactive and learner-centered teaching and learning contexts [7].

New competencies are created for students, the key to the progress of sustainable development. These competencies are systemic thinking, anticipation, normative, strategic, collaborative, critical thinking, self-awareness, and integration of problem-solving [8].

New competencies are created for teachers involved in education for sustainable development. These are: understanding the discourse and practice of ESD in its local, national, and global context, adopting disciplinary, interdisciplinary, and transdisciplinary perspectives, practicing a transformative action-oriented pedagogy that involves students in participatory thought and action processes, identify local learning opportunities related to sustainable development, and establish collaborative relationships and evaluate and measure the development of students in transversal sustainability skills, among others [10].

The example outlined about raw materials in a country with resources such as Cuba illustrates the importance of putting these actions into practice in order not only to meet the objectives but also to easily achieve the social license that is so important today. This proposed methodology is just one more step in the proposals for educational innovation in technical careers.

4 CONCLUSIONS

Target 4.7 of the SDGs for 2030 speaks of ensuring that all students acquire the theoretical and practical knowledge necessary to promote sustainable development, including through education for sustainable development and the adoption of sustainable lifestyles, human rights, gender equality, the promotion of a culture of peace and non-violence, world citizenship and the appreciation of cultural diversity and the contribution of culture to sustainable development, among other means [2].

Regarding the application of the proposed methodology:
• The designed methodology can be applied to any company in any sector since the system seeks to evaluate the efforts and initiatives that graduates of technical careers and companies are capable of implementing.

• The publication of the results obtained when implementing the methodology in real projects facilitates the analysis and identification of the strengths and weaknesses of the companies. The fact that a company discloses this type of information to stakeholders and the community, in general, helps to facilitate the understanding of the efforts made by the company in the face of these challenges.

• Finally, integrating this way of working similar to good practices in the training phase of technical careers, facilitates rapid assimilation by companies and society in general, accelerating the social changes necessary to achieve the objectives set.

Regarding the current tools that assess the level of compliance with the goals and objectives of sustainable development in companies or the quality of higher education:

• To date, there is a wide range of sustainability evaluation tools, however, none is capable of carrying out a quantitative and qualitative evaluation of the performance of the entire spectrum of companies at the same time.

• Among the mentioned tools, the Dow Jones Sustainability Index is the most complete and respected, however, for a company to be evaluated with this tool it must meet demanding conditions, which many of the companies that belong to the industry are far from complying.

• In the world, there are practically no regulations that are aimed at achieving sustainability in the industry, although, in Spain, different associations have collaborated in the creation of regulations in this regard, which, although currently optional, it would not be strange if it happened to be a mandatory regulation in that country.

• There is no globally recognized barometer to measure sustainability, but there is no doubt that the Sustainable Development Goals (SDGs), set by the United Nations (UN), are the most widely accepted conceptualization worldwide of the different edges that are associated with sustainability.

• It is clearly established that the raw materials industry, in its actions, has a close relationship with the SDGs and that, in addition, it can and must contribute to the fulfillment of each one of them.

• In the absence of a sustainable management system or tool that is capable of applying to every company in the industry, bearing in mind that most of these companies can be considered "medium" and many of them are not listed on the stock market, the need arises to create a sustainable management system or tool tailored to these companies and allow them to measure their performance.

• When trying to see the degree of achievement of the SDGs, we concluded that there are no indicators, in the field of mining, that allows measuring the degree of fulfillment of each of the objectives.

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