**Title:** SIA as a tool to take balanced decisions in the development of Engineering Projects

**Abstract:**

The practice of engineering is one of the areas where a greater balance is needed between the scientific, technological, social, environmental and economic aspects that affect decision making. This balance between the various factors should be present in all phases of the project life cycle: from the definition of objectives, problems or opportunities that justify the project, to the formulation of alternatives, the choice of agents involved in the decision or the decision process itself. However, in practice, in the field of engineering there is a monopoly of technological and economic criteria as determinants of the decision. This situation contrasts with the official discourse that emphasizes the incorporation of social, health and safety, environmental, economic, political and cultural restrictions in the analysis, design and practice of engineering. In fact, this official discourse is present in the definition of the abilities that must be acquired during the official training processes of engineering students. This gap between official discourse and actual practice is particularly serious, especially since evidence shows that the social impacts of a technology throughout the life cycle of a product, equipment or system can have negative effects that undermine the human rights of individuals and communities, especially women and children, as has been shown in technologies such as electronics. To eliminate, mitigate or reduce these effects, as well as to enhance positive impacts, it is necessary to generalize the evaluation of the social impact of technological projects and, therefore, to include contents on this subject in the education and professional practice of engineering. This evaluation must be carried out during all the phases of a project: initiation, planning, execution and closure. This paper recommends, in addition to the justification, a proposal for the integration of the SIA in the development of an engineering project.

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**Introduction**:

> *"As a creative and scientific activity that transforms nature to serve the needs and wants of large numbers of people, engineering has both physical and human dimensions. To modify nature effectively as desired requires*

> *mastery of natural laws and phenomena, thus engineering shares the contents and standards of natural science. To ascertain what modifications are desirable requires an understanding of human and socioeconomic factors, thus engineering goes beyond natural science in its missions of utility and service.*"(Auyang, 2006, p. 2)

As stated in the previous paragraph, the engineering profession deals with multiple activities that have to do with fields as diverse as science, technology, economics, environment and society. The integration of all these dimensions is complex and requires a proper balance between them, particularly the social aspects.

Thus, among the criteria for accreditation of engineering degrees in several countries (Whashington Accord) is the acquisition of engineering skills that take into account cultural, social and health and safety considerations, as we can see in the following statement: "*WA3: Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations. (WK5)*" (International Engineering Alliance, 2013, p. 10)

In general, social aspects are considered as soft within the curriculum and, as evidenced in several longitudinal studies, do not seem to achieve the intended objective (Cech, 2014; Rulifson & Bielefeldt, 2019). Moreover, the content of subjects with social references is separated from the content of purely technological subjects (Vanderburg & Khan, 1994), with the result that the engineering student learns that in engineering design, social aspects are not central. They are important, but they belong to another field of activity or knowledge.

Furthermore, if we look at the social impacts related to a technological industry such as the electronics industry, we find that throughout the life cycle of an electronic device there are harmful social impacts, such as:

- *Raw material extraction*: extreme violence; women and children rape; slave and child work.
- *Manufacturing*: work long hours (12-14); work with hazardous substances without protective equipment; employer holds their wages; they are not provided a contract. Also, dormitories are an extension of labour control.
- *Discard*: Export of toxic material to less developed countries; uncontrolled e-waste processing operations caused serious pollution to local soils and vegetables.

To avoid these and other possible negative impacts, the social impact assessment methodology should be included in the development of engineering projects.

**Proposal**:

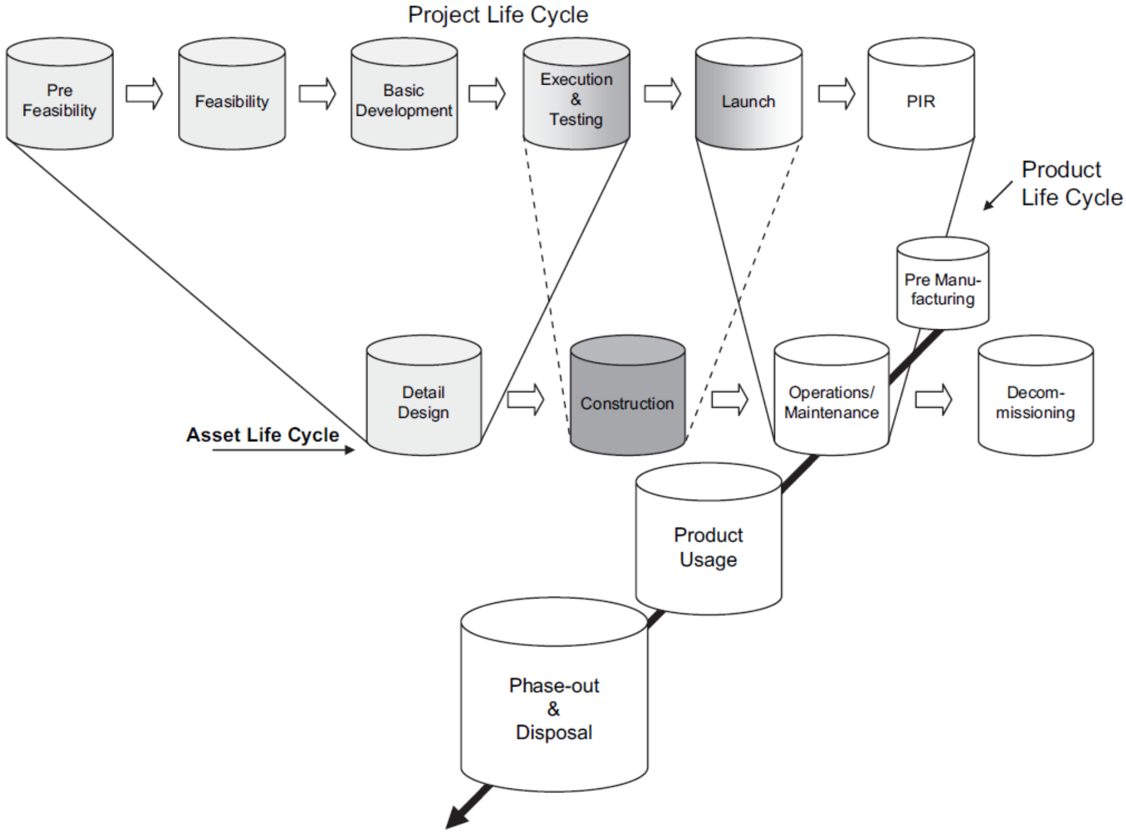


*Fig. 1 Project, Asset (or Process) and Product Life Cycles (Labuschagne & Brent, 2008)*

There is a wide variety of engineering interventions with different contexts, objectives and needs. For example, a project may involve the operation of a mine, the design of a manufacturing plant or a production line, the design of a printed circuit board or a computer program. We cannot aspire to present a precise methodology to fit all the needs posed by these different scenarios. On the contrary, the methodological aspects of the proposal are generic and common to most of the different types of interventions.

The proposal follows the three interrelated life cycle approach of Labuschagne y Brent (2008): the project, process and product life cycle. We think that this approach is very appropriate because it shows how the decisions taken in the development of the project affect the rest of the life cycles, and this is done from the very beginning of the project.

Although the project life cycle proposed by Labuschage and Brent contains six stages, in this article we adopt the Project Management Institute's proposal (2017) to consider four main phases: initiation; planning; execution, monitoring and control; and closure. Thus, the initiation stage of the proposal incorporates the stages defined as pre-feasibility and feasibility in the Labuschage and Brent approach; the planning stage would correspond to the basic development stage; the execution stage would include the execution, testing and launch stages; and the closure stage would correspond to the Post Implementation Review (PIR).

Although social impacts appears all throughout the project, also at the very beginning of the project where even a rumour that something is going to be done could trigger some important effects (The Interorganizational Committee on Principles and Guidelines for Social Impact Assessment, 2003) , the main impacts of the integrated life cycles happens during the execution, operation (that includes the product life cycle) and decommissioning of the process (Labuschagne & Brent, 2008).

From the engineering point of view, we adopt the concurrent engineering perspective. It is an engineering project management concept that promotes the consideration of all project requirements from the beginning of the project to the end. Among others these requirements include: performance, reliability, quality, customer use, marketing and sales, manufacturing and financial issues.

a) Phase I: Initiation

During this phase a community, society (at local, regional or national level) or business necessity, problem or opportunity is identified. Interested and affected parties (stakeholders) are recognized in an iterative process as different perspectives on the problem/opportunity situation could emerge. Characterizing stakeholders and stakeholder's participation is not an easy step as it should include all that appears in the different phases of the project life cycle. As an example, electronic products include affected parties during the mining, manufacturing, use, and discard phases all over the world. Two main approaches can be identified: stakeholder management with the project as the main goal where public participation is perceived as problematic for the project and stakeholder management where stakeholders have a significant positive role in the project.

A baseline study is conducted to describe the present situation so that changes can be compared with the future situation after the development of the project.

Once the problem or opportunity is identified various alternatives are defined. Next, a feasibility study is conducted to investigate whether each option addresses the problem or opportunity and a final recommended alternative is then put forward. If no alternative seems feasible, then a very different approach should be recommended and another project should be initiated. The feasibility study includes:

- Market, process and product information: market segment and size; competition and similar products; sales process; product support; customer profile; physical and market environment; …
- Technical issues: the overall capacity to exploit, design and manufacture the product or process; innovation level required; previous experience; new components, techniques or knowledge; specific manufacturing or quality issues expected or required; size of the project; …
- Economic and financial aspects: determine the resources required and simulate their financing and simulate the evolution of the investment over the estimated life of the project.

- Environmental and social impacts: foreseeable direct or indirect; cumulative and synergistic effects of the project over the environment and the society.

Once and if the recommended solution is approved, a project is initiated to deliver the solution. Terms of reference are completed outlining the objectives, scope and structure of the project; a project manager is appointed and a team recruited.

A baseline study is conducted to describe the present situation so that changes can be compared with the future situation after the development of the project.

Approval of the activities develop in this phase is then sought to move into the detailed planning phase.

From the point of view of the social impact of a project, during this phase the following activities should be carried out: Involve interested and affected parties (stakeholders, public participation); problem identification; description of the proposed action; baseline study; scope (study of possible impacts during the life cycle), investigation of probable impacts, secondary and cumulative impacts; responses of interested and affected parties to impacts; and alternatives to the proposed action.

b) Planning

Once the scope of the project has been defined in the terms of reference, the project enters the detailed planning phase. Its main goal is to define all the information, with the maximum detail possible, needed to develop the project during the execution phase. This involves creating a:

- project plan with the Work Breakdown Structure (WBS) outlining the activities, tasks, dependencies and project schedule;
- requirement determination, documenting and management, including labour, equipment and materials required;
- financial/cost plan identifying the labour, equipment and materials costs;
- quality plan providing quality targets, assurance and control measures;
- risk plan highlighting potential risks negative/positive and actions to be taken to mitigate/exploit those risks;
- acceptance plan listing the criteria to be met to gain stakeholder acceptance;
- communications plan describing the information needed to inform stakeholders;
- procurement plan identifying asset, products or services needed from external suppliers.
- Stakeholders plan that involves stakeholders in project decisions and execution.
- Environmental and social impact management plan.

At this point the project will have been planned in detail and is ready to be executed.

From the point of view of a project social impact, the activities to be carried out during this phase include the following: summary of the previous social impact assessment; list of identified impacts (positive and negative), phase, stakeholders involved, type of impact, probability, consequences, responsible parties, and indicators; Developing of the Social Impact Management Plan (SIMP) with the definition of both monitoring and reporting strategies and mitigation and management strategies.

c) Execution, monitoring and control

This phase consists of executing the plans created during the project planning phase. An annual operational plan is defined with the activities to be carried out each year following the designed planning. As each plan is executed, a series of management processes are carried out to monitor and control project results. This includes identifying changes, risks or any other issues that could trigger a needed response; reviewing the quality of deliverables, and measuring each deliverable produced against acceptance criteria. Once all deliverables have been produced and the customer has accepted the final solution, the project is ready for closure.

From the point of view of the social impact of a project, the activities to be undertaken during this phase includes monitoring and mitigation. Monitoring (SIMP follow-up) activities include: compare actual and projected impacts; detect deviations from the proposed action and unanticipated social impacts; and determine the nature and extent of actions needed when the impact is greater than expected. Mitigation with different responses like: avoid the impact without modifying the action; minimize, rectify or reduce the impact by redesigning or operating the project; compensate for irreversible impacts through substitution policies, services, resources or opportunities; rare situations could involve redesign or closure of the project.

d) Closure

Project closure is the process of completing all project activities, finalizing contracts and releasing all resources. The end of the project is communicated to all stakeholders. An evaluation is then conducted to quantify the level of project success and identify lessons learned for future projects.

From the point of view of the social impact a project evaluation with two main approaches will be carried out. a) Testing the effectiveness and cost effectiveness of SIA, and lessons learned to improve the process of conducting SIA in future projects b) Social impact assessment (post-implementation review) of the project outcome. This last assessment should be conducted, if possible, several months/years after the finalization of the project to check if the object of the project has improved the situation as expected.

**Conclusion**

Engineering encompasses processes and activities in which decision making that involves different fields of knowledge are present and where the social aspects are underrepresented. There is a contradiction between, on the one hand, the professional and educational stance, which considers the social aspects related to professional practice as essential, and, on the other hand, the engineering practice that does not sufficiently take into account the social effects of its activities. This paper has presented a proposal for the integration of social impact assessment in engineering project management to facilitate the closing of this gap.

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