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

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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 education 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 it 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.

Keywords: Social Impact Assessment, Project Management, Engineering Projects

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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 among them, particularly the social aspects.

Thus, among the criteria for accreditation of engineering degrees in several countries (Washington 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 competences 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*: long working hours (12-14); work with hazardous substances without protective equipment; employer holds their wages; absence of formal working contracts. Also, dormitories are an extension of labour control.
- *Discard*: Export of toxic material to less developed countries; serious pollution in local soils, water and air due to uncontrolled e-waste processing operations.

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

Proposal:

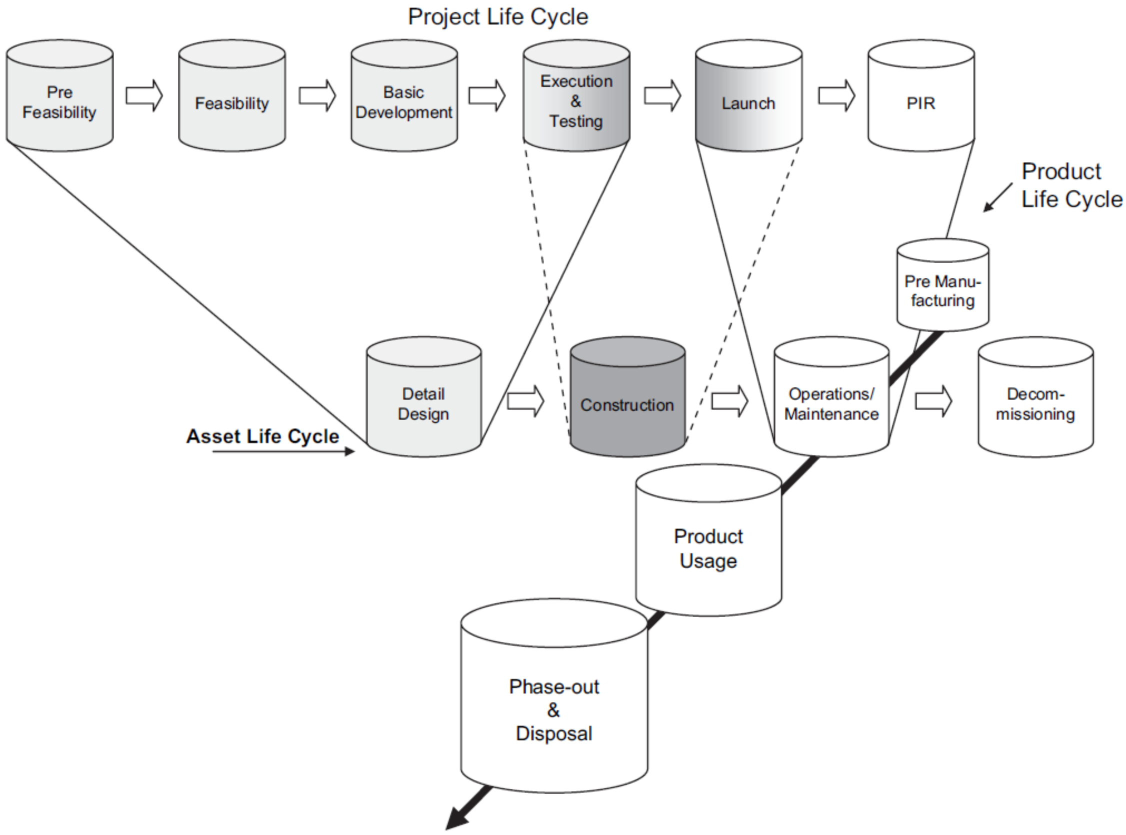

Fig. 1 Project, Asset (or Process) and Product Life Cycles (Labuschagne & Brent, 2008)

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 the wide variety 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 shape the rest of the life cycles, and this is done from the very beginning of the project.

Although the project life cycle proposed by Labuschagne 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 merges the stages defined as pre-feasibility and feasibility in the Labuschagne and Brent approach; the planning stage corresponds to the basic development stage; the execution stage includes the execution, testing and launch stages; and the closure stage corresponds 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 need, problem or opportunity is acknowledged. Stakeholders have to be identified in an iterative process as different perspectives on the problem/opportunity situation could emerge. Characterizing stakeholders and defining stakeholder's participation is not easy as it should include all that appears in the different phases of the project life cycle. For 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 carried out 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 examine whether each alternative addresses the problem or opportunity and a final recommended option is put forward. If no alternative seems feasible, then a 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 of 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 required financial resources, analyse the sources of financing and simulate the evolution of cash flows over the estimated life of the project.
- Environmental and social impacts: foreseeable direct or indirect; cumulative and synergistic effects of the project over environment and society.

After the approval of the recommended solution, a project is launched to deliver the intended solution. Terms of reference are completed outlining the objectives, the scope and the structure of the project; a project manager is appointed and a team recruited.

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 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 proposed actions.

Once the activities of the initial phase are approved, the project enters into the detailed planning phase.

b) Planning

At this point, the scope of the project has been defined in the terms of reference. The main goal of this phase is to compile all the information required for the future develop of the project, especially the execution phase. This involves a description, with the maximum detail possible of:

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

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), phases, involved stakeholders, type of impacts, 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.

Once all the needed information is adequately gathered, the project is ready to pass the next phase.

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 during each year of the project, following the designed planning. As each annual 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.

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: avoiding the impact without modifying the action; minimizing, rectifying or reducing the impact by redesigning or operating the project; compensating for irreversible impacts through substitution policies, services, resources or opportunities; rare situations could involve the redesign or closure of the project.

Once all deliverables of the project are produced and the customer accepts the final solution, the project is ready for its closure.

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 approach should be conducted, if possible, several months/years after the finalization of the project to check whether 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 reduce this gap.

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